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Agronomic Evaluation and Economic Analysis of Winter Maize under Different Plant Population and Nitrogen Rates in Chitwan, Nepal

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ABSTRACT

In order to find out the effect of different levels of nitrogen and plant population on maize growth and productivity, a field experiment was carried out at Anandapur, Mangalpur VDC-3, Chitwan during winter season of 2006/07. Five levels of nitrogen: 0, 50, 100, 150 and 200 kg N/ha and three levels of plant population: 55,555, 66,666 and 83,333 plants/ha were used in the experiment. Agronomic characters like plant height, stem diameter and leaf area index increased with higher levels of nitrogen but decreased with lower levels of plant population at all observations. The number of cobs/plant, cob length, cob diameter, number of grain rows/cob, number of grains/grain row and number of grains/cob, thousand grain weight were increased under higher levels of nitrogen but decreased under higher levels of plant population. Significantly higher grain yield (6514.48 kg/ha), net return (Rs. 42188.74 /ha) and benefit: cost ratio (1.67) were obtained under 200 kg N/ha and 66,666 plants/ha. Similarly the population level of 66,666 plants/ha gave significantly highest grain yield (5113.46 kg/ha), net return (Rs. 25812.28/ha and benefit: cost ratio (1.44).

Key words: *Zea mays* L., Nitrogen, Plant population, Growth, Yield

INTRODUCTION

Maize (*Zea mays* L.) is the world's widely grown cereal and primary staple food crop in many developing countries. In Nepal, it is the second most important cereal crop in terms of both area and production, and the first staple food crop in the hills. Maize occupies about 28.32% of the total agricultural land cultivated, and shares about 23.89 % of the total cereal production in Nepal (MoAC, 2009/10). The proportion of maize area consists of 70.23% in hills followed by 19.32% in Terai and 10.45% in mountain (MoAC, 2009/10). It is grown in 875,660 hectares of land with average yield of 2.119 t/ha (MoAC, 2009/10) which is very low compared to neighbouring countries. The maintenance of low plant population in maize fields is one of the major factors affecting low productivity of maize in Nepal. Since yield of a crop is the result of final plant population, the establishment of optimum plant population is essential to get maximum

yield. The competition between plants may not occur, and resources are not efficiently used at very low plant population. Under low plant population, grain yield is limited by inadequate number of plants whereas at higher plant population, it declines mostly because of an increment in the number of aborted kernels and/or barren stalks. At higher plant population, the rate of yield reduction is in response to decreasing light, moisture nutrient and other environmental resources available to each plant. Nepalese farmers have been practicing broadcasting method of seed sowing, which can not maintain uniform plant population in the field. The maintenance of plant population of maize in farmer's field condition is lower than the recommended level; and hence the yield is reduced. This is one of the causes of lower maize yield in Nepal.

The chemical fertilizer especially nitrogen fertilizer is universally accepted as a key component to higher corn yield and optimum economic return (Gehl, et al., 2005). The loss of soil fertility and lower use of fertilizer input is also another important factor responsible for low yield of maize. The amount of nitrogen to be applied depends largely on the plant population/unit area of land. Optimum high plant population can result in increased production only if there is proper supply of nutrients, particularly nitrogen. Srivastav, et al. (2002) found non-significant response of early and late varieties to three levels of N (60, 90 and 120 kg/ha) and plant densities (53000, 71000 and 95000 plants/ha) during summer but a significant response during winter season. Adhikari, et al. (2004) reported that the highest grain yield of 9352 kg/ha was produced when the crop was fertilized with 120 kg N/ha on the crop planted under the plant population of 53,333 plants/ha; and they noted the lowest yield (6657 kg/ha) with the crop supplied with 60 kg N/ha under plant population of 44,444 plants/ha.

Winter maize has higher production potential than the rainy season maize. In some Terai areas of Nepal, cultivation of winter maize started commercially and the information regarding optimum levels of nitrogen and plant population on winter maize is not sufficient in our country. So winter season maize has been selected to find out the effects of different levels of nitrogen and plant population on growth and development of maize and to assess the net returns and B:C ratios

MATERIALS AND METHODS

For the experimentation, Rampur Composite variety was planted at Anandapur, Mangalpur VDC-3, Chitwan during September 2006 to February 2007. Fifteen treatment combinations consisting of five levels of nitrogen (0, 50, 100, 150 and 200 kg N/ha) and three levels of plant population (55,555 plants/ha, 66,666 plants/ha and 83,333 plants/ha) were replicated three times and laid out in a randomized complete block design. Row to row spacing was maintained at 60 cm for each plot. Plant to plant spacing was maintained at 30, 25 and 20 cm for 55,555 plants/ha, 66,666 plants/ha and 83,333 plants/ha respectively. The net harvested area for research was 7.5 m². Before sowing, the soil of the research field was tested in Soil Science Division, Khumaltar and then maize was

sown. The research field has sandy silt loam, strongly acidic soil (pH 5.13), medium in total nitrogen (0.123%), high in soil available phosphorous (77.56 kg/ha), low in soil available potassium (23.25 kg/ha) and high in organic matter content (1.85%). Fertilizer in the form di-amonium phosphate (DAP), and murate of potash (MoP) was applied @:60:40 P₂O₅:K₂O kg /ha. Entire dose of DAP and MoP was applied at the time of sowing while half of urea was first top dressed at knee high stage and second top dressed at tasseling stage. At maturity central two rows from each plot were separately harvested and the fresh ear weight was measured in each plot. Grains were shelled from five randomly selected cobs to observe the percent grain moisture at harvest for each plot. Grain yield kg ha⁻¹ was calculated for every entry from the data of fresh ear weight per plot using the following formula:

$$\text{Grain Yield (Kg/ha) at 15 \% moisture} = \frac{\text{Fresh ear weight (Kg/ha)} \times (100-\text{MC}) \times 10,000}{(100-15) \times 7.5}$$

Where:

MC = moisture content in grains at harvest (%)

0.8 = Shelling co-efficient

Area of harvested plot= 7.5 m²

1 hectare = 10,000 m²

15 % = moisture content required in maize grain at storage

Observations were taken on plant height, stem diameter, leaf area index at 90 days after sowing. The number of cobs/plant was taken at the time of harvesting. Data regarding the cob length, cob diameter, number of grain rows/cob, number of grains/grain row and number of grains/cob were taken after harvesting.

RESULTS AND DISCUSSION

Growth characters

The growth characters namely plant height, stem diameter and leaf area index as influenced by different levels of nitrogen and plant population are presented in Table 1. The lowest plant heights of 1.99 m were observed under control (0 kg N/ha) and the highest plant height 2.56 m were observed under 200 kg N/ha, respectively. Plant height significantly increased only up to 150 kg N/ha. Statistically similar plant heights were found under 150 kg N/ha and 200 kg N/ha. With each increment in level of plant population, there was significant (p<0.05) reduction in plant heights in all observations. Significantly lowest plant heights of 2.28 m under 83,333 plants/ha and the highest plant heights of 2.46 m under 55,555 plants/ha were observed, respectively.

The plant height decreased with the increasing level of plant population. This was due to severe competition between plants for resources that occurred under higher plant stands. Sharma (1973) observed that increasing nitrogen dose from 0 to 150 kg N/ha

increased the plant height from 1.64 to 2.09 m. Nitrogen being a constituent of chlorophyll and enzymes necessary for photosynthesis and vegetative growth, higher level of nitrogen increased the vegetative growth, extension of stem, leaf and thus increased plant height. Diallo, et al. (1996) reported a decreased plant height of maize under lower doses of N supply. The reduction in plant height under reduced levels of N fertility level might be due to the reduction in growth in plants.

Statistically highest stem diameters (2.67 cm) under 200 kg N/ha and the lowest stem diameters (2.06 cm) under 0 kg N/ha were recorded, respectively. Stem diameter significantly increased only up to 150 kg N/ha, which was at par with that of 200 kg N/ha. Similarly, lower plant population of 55,555 plants/ha produced highest stem diameters of 2.46 cm which were significantly higher than those obtained under medium plant population of 66,666 plants/ha and higher plant population of 83,333 plants/ha respectively. The stem diameter obtained under 55,555 plants/ha was statistically higher than that of 83,333 plants/ha but that was at par with stem diameter obtained under 66,666 plants/ha. Thakur, et al. (1997) reported increased stem diameter of maize with the increasing N levels. The increment in stem diameter with increasing N levels was mainly due to rapid cell division and cell multiplication that occurred in the stem. Under higher plant stands competition between plants occurred to great extent. Therefore, stem diameter reduced with increasing plant stands.

The highest leaf area index (LAI) under 200 kg N/ha and the lowest LAI under 0 kg N/ha were obtained. The research findings revealed that the highest LAI (3.67) under 200 kg N/ha and the lowest LAI (2.11) under 0 kg N/ha were found respectively. With each increment in level of plant population, there was significant increment in LAI at all observations. Significantly lowest LAI (2.77) under the lowest plant population of 55,555 plants/ha and the highest LAI (3.48) under the highest plant population of 83,333 plants/ha were observed respectively. Athar (1979) reported increased LAI with increasing level of plant population. Under low planting density, crop canopy was open, therefore LAI was low whereas under high planting density crop canopy was closed, and therefore LAI was high. When plants were spaced closely, leaf surface/plant was reduced. Therefore, LAI was also low. The higher plant population increased the LAI. Significant increment in LAI due to increasing levels of plant population was observed at all observations.

Grain yield and yield attributing characters

Various yield components of maize as influenced by different levels of nitrogen and plant population are presented in Table 2. The number of cobs/plant, cob length, cob diameter, number of grain rows/cob, number of grains/grain row, number of grains/cob and thousand grain weight significantly increased with increasing levels of nitrogen upto 200 kg N/ha but decreased with each increment in plant population level from 55,555 plants/ha to 83,333 plants/ha. Significantly highest number of cobs/plant (1.09), cob

length (15.90 cm), cob diameter (5.10 cm), number of grains/grain row (32.54), number of gain rows/cob (14.11) and number of grains/cob (459.9) and thousand grain weight (318.2 g) were obtained under 200 kg N/ha. The lowest number of cobs/plant (1.00), cob length (9.94 cm), cob diameter (4.26 cm), number of grains/grain row (21.33), number of gain rows/cob (12.11) and number of grains/cob (259.0) and thousand grain weight (238.1 g) were obtained under control nitrogen (0 kg N/ha).

Table 1 Plant height, stem diameter and leaf area index under different nitrogen levels and plant population

Treatments	Plant height (m)			Stem diameter (cm)			Leaf area index		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
<u>Nitrogen levels</u>									
0 kg N/ha	1.05 ^e	1.91 ^d	1.99 ^d	1.90 ^d	2.11 ^e	2.06 ^d	1.43 ^e	2.57 ^e	2.11 ^e
50 kg N/ha	1.15 ^d	2.28 ^c	2.33 ^c	2.18 ^c	2.33 ^d	2.28 ^c	1.76 ^d	3.36 ^d	2.97 ^d
100 kg N/ha	1.26 ^c	2.41 ^b	2.46 ^b	2.23 ^c	2.50 ^c	2.38 ^b	2.05 ^c	3.55 ^c	3.17 ^c
150 kg N/ha	1.35 ^b	2.46 ^b	2.55 ^a	2.40 ^b	2.70 ^b	2.59 ^a	2.32 ^b	3.82 ^b	3.42 ^b
200 kg N/ha	1.41 ^a	2.53 ^a	2.56 ^a	2.58 ^a	2.83 ^a	2.67 ^a	2.47 ^a	4.43 ^a	3.67 ^a
SEm (±)	0.010	0.018	0.021	0.025	0.021	0.029	0.014	0.063	0.547
LSD _(0.05)	0.030	0.052	0.061	0.074	0.061	0.086	0.043	0.183	0.158
CV (%)	2.44	2.52	2.49	3.45	2.67	3.84	2.30	5.37	5.34
<u>Plant populations</u>									
55,555 plants/ha	1.30 ^a	2.40 ^a	2.46 ^a	2.34 ^a	2.56 ^a	2.46 ^a	1.93 ^c	3.21 ^c	2.77 ^c
66,666 plants/ha	1.24 ^b	2.32 ^b	2.39 ^b	2.27 ^b	2.50 ^b	2.41 ^a	2.01 ^b	3.51 ^b	2.96 ^b
83,333 plants/ha	1.19 ^c	2.23 ^c	2.28 ^c	2.16 ^c	2.43 ^c	2.32 ^b	2.09 ^a	3.92 ^a	3.48 ^a
SEm (±)	0.008	0.014	0.016	0.020	0.016	0.051	0.011	0.048	0.042
LSD _(0.05)	0.023	0.040	0.047	0.057	0.047	0.149	0.033	0.141	0.122
CV (%)	2.44	2.52	2.49	3.45	2.67	3.84	2.30	5.37	5.34

Means followed by the common letter within each column are not significantly different at 5% level of significance by DMRT.

Significantly highest number of cobs/plant (1.08), cob length (13.79 cm), cob diameter (4.82 cm), number of grains/grain row (28.91), number of gain rows/cob (13.61) and number of grains/cob (396.7) and thousand grain weight (287.41 g) were obtained under 55,555 plants/ha. The lowest number of cobs/plant (1.02), cob length (12.35 cm), cob diameter (4.53 cm), number of grains/grain row (26.19), number of gain rows/cob (12.48) and number of grains/cob (330.0) and thousand grain weight (271.23 g) were obtained under 83,333 plants/ha.

Table 2 Yield attributing characters of maize under different nitrogen levels and plant population

Treatments	No. of cobs/plant	Cob length (cm)	Cob diameter (cm)	Number of grains/row	Number of grain rows/cob	Number of grains/cob	Thousand grain weight (g)
<u>Nitrogen levels</u>							
0 kg N/ha	1.00 ^e	9.94 ^e	4.26 ^e	21.33 ^e	12.11 ^c	259.0 ^e	238.1 ^e
50 kg N/ha	1.03 ^d	11.91 ^d	4.50 ^d	25.24 ^d	12.60 ^b	318.8 ^d	263.0 ^d
100 kg N/ha	1.05 ^c	12.89 ^c	4.59 ^c	27.52 ^c	12.86 ^b	354.5 ^c	277.8 ^c
150 kg N/ha	1.07 ^b	14.85 ^b	4.96 ^b	31.23 ^b	13.68 ^a	428.2 ^b	297.9 ^b
200 kg N/ha	1.09 ^a	15.90 ^a	5.10 ^a	32.54 ^a	14.11 ^a	459.9 ^a	318.2 ^a
SEm (±)	0.002	0.165	0.038	0.241	0.151	5.29	1.524
LSD _(0.05)	0.007	0.478	0.110	0.698	0.439	15.34	4.415
CV (%)	0.79	3.79	2.44	2.62	3.48	4.36	1.64
<u>Plant Populations</u>							
55,555 plants/ha	1.08 ^a	13.79 ^a	4.82 ^a	28.91 ^a	13.61 ^a	396.7 ^a	287.41 ^a
66,666 plants/ha	1.04 ^b	13.15 ^b	4.69 ^b	27.62 ^b	13.13 ^b	365.5 ^b	278.32 ^b
83,333 plants/ha	1.02 ^c	12.35 ^c	4.53 ^c	26.19 ^c	12.48 ^c	330.0 ^c	271.23 ^c
SEm (±)	0.002	0.128	0.029	0.186	0.117	4.10	1.18
LSD _(0.05)	0.006	0.371	0.085	0.540	0.340	11.89	3.42
CV (%)	0.79	3.79	2.44	2.62	3.48	4.36	1.64

Means followed by the common letter within each column are not significantly different at 5% level of significance by DMRT.

The research findings showed that significantly highest grain yield (6514.48 kg/ha) and the lowest grain yield (2557.28 kg/ha) were produced under 200 kg N/ha and under 0 kg N/ha, respectively. The successive increment in nitrogen rate from 0 to 200 kg N/ha significantly increased the grain yield. The application of 50, 100, 150 and 200 kg N/ha increased 62.11, 104.74, 135.68 and 154.74% higher grain yield over control (0 kg N/ha), respectively. Similarly, grain yield (5113.46 kg/ha) obtained under plant density of 66,666 plants/ha (60 cm x 25 cm spacing) was significantly higher than that of 55,555 plants/ha (60 cm x 30 cm spacing) but that was at par with yield of 83,333 plants/ha (60 cm x 20 cm spacing). The grain yield obtained under 66,666 plants/ha and 83,333 plants/ha was higher by 15.53 and 16.33% over yield of 55,555 plants/ha, respectively. The increment in grain yield with the increment in plant population was significant only up to plant population of 66,666 plants/ha.

Yadav (1990) noted the significant increment in grain yield of maize with successive increment in the levels of nitrogen from 0 to 90 kg N/ha. The increasing maize yield was obvious, considering the higher nitrogen requirement and its vital role in the metabolism of maize. Significant increment in grain yield of maize with successive increment in nitrogen rates may be attributed to significant increment in all the yield attributes i. e. cob number/plant, cob length, cob diameter, number of grains/grain row,

number of grain rows/cob, test weight. Under highest plant population, grain yield did not increase. This was because of reduction in yield/plant with increasing plant population under very high plant population. Duncan (1958) reported decreased yield/plant as the density/unit area increased. Under higher plant densities, the rate of yield reduction was in response to decreasing light, moisture nutrient and other environmental resources available to each plant. Reduction in yield was mostly due to lower number of ears (barrenness) (Bunting, 1973), fewer kernels/ear (Baenziger and Glover, 1980), lower kernel weight (Poneleit and Egli, 1979), or a combination of these components.

Table3 Grain yield under different nitrogen levels and plant population

Treatments	Grain yield (kg/ha)
<u>Nitrogen levels</u>	
0 kg N/ha	2557.28 ^e
50 kg N/ha	4145.77 ^d
100 kg N/ha	5235.84 ^c
150 kg N/ha	6027.05 ^b
200 kg N/ha	6514.48 ^a
SEm (±)	71.2
LSD _(0.05)	206.3
CV (%)	4.36
<u>Plant densities</u>	
55,555 plants/ha	4425.92 ^b
66,666 plants/ha	5113.46 ^a
83,333 plants/ha	5148.88 ^a
SEm (±)	55.16
LSD _(0.05)	159.8
CV (%)	4.36

Means followed by the common letter within each column are not significantly different at 5% level of significance by DMRT

Economics analysis

The increment in net return and B: C ratios due to increment in nitrogen levels from 0 to 200 kg N/ha were significant. The net return obtained under 200 kg N/ha was 13.93, 54.52, 222.04 and 578.90% higher than that of 150, 100, 50 and 0 kg N/ha, respectively. The net return increased with increasing level of plant population. The net return (Rs.25812.28/ha) obtained under 66,666 plants/ha was significantly higher than that of 55,555 plants/ha but was at par with that at 83,333 plants/ha. The net returns given by the plant population of 66,666 plants/ha was higher by 10.19 and 49.64% than that of 83,333 plants/ha and 55,555 plants/ha, respectively. The highest benefit: cost ratio (1.67) obtained under 200 kg N/ha was at par with that of 150 kg N/ha and the lowest B:C ratio (0.82) was observed under 0 kg N/ha (Table 4).

Table 4 Net return and B: C ratio at different nitrogen levels and plant population

Treatments	Net return (Rs/ha)	B:C ratio
<u>Nitrogen levels</u>		
0 kg N/ha	-8809.50 ^e	0.82 ^e
50 kg N/ha	13100.35 ^d	1.24 ^d
100 kg N/ha	27301.42 ^c	1.48 ^c
150 kg N/ha	37027.66 ^b	1.62 ^b
200 kg N/ha	42188.74 ^a	1.67 ^a
SEm (±)	1131.63	0.014
LSD _(0.05)	3278.2	0.043
CV (%)	15.3	4.67
<u>Plant densities</u>		
55,555 plants/ha	17249.19 ^b	1.29 ^c
66,666 plants/ha	25812.28 ^a	1.44 ^a
83,333 plants/ha	23423.72 ^a	1.37 ^b
SEm (±)	876.56	0.011
LSD _(0.05)	2539	0.033
CV (%)	15.3	4.67

Means followed by the common letter within each column are not significantly different at 5% level of significance by DMRT

CONCLUSION

Among the different levels of plant population and nitrogen rates tested on maize during winter season of 2006/07 at Mangalpur-3, Chitwan, the application of 200 kg N/ha and plant population of 66,666 plants/ha gave higher grain yield and maximum profit (net return and benefit/cost ratio). Therefore, maintaining this levels of nitrogen and plant population is very much important to receive maximum profit in this enterprise.

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IPM Field School in Cucurbit Crop: A Participatory Teaching Learning Process in Academic Institutions

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ABSTRACT

The field school trains farmers in analyzing their own environment and farming practices, thereby enabling them to make decisions on crop management based on observations and to use the resources that fit with their environment and farming systems. Through experimentation, observation, discussion and decision making farmers increase their crop management skills. The learning module developed by farmers field school were incorporated in Student Field School to provide the practical knowledge about IPM at the academic level and develop the trained and capacious manpower on IPM through student field school approach. A 24 weeks field school was conducted targeting students and teachers of IAAS in cucurbit crops (Bittergourd) from Chitra to Shrawan, 2067. Various crop management practices with adopting many learning modules like comparative study in mandatory and supportive trial, BBT (Pre-test and Post-test), Insect drawing, Zoo and cage study, Pot culture, Life cycle and food web study, Comparisons on IPM and FFS, Root vessel study, Pest monitoring and group dynamics practices helps the participants to update their knowledge and facilitates the teaching learning process. Moreover, IPM practice was better than FM in term of growth parameters like plant height, leaf number and male and female flower ratio. Pest incidences in both practices were more or less similar however; the activity of beneficial insects was higher in IPM plot. Cue lure was found to be better monitoring tools of cucurbit fruit fly. Hence, field school is one of the better extension tools of IPM in academic institutions where judicious pest management practices are applied with considering the environment and sustainable agriculture.

Key words: Integrated pest management, IPM, Field school, AeSA

INTRODUCTION

Fields School (FS) is a model approach for educating farmers/groups which usually comprises a season long regular meetings with a set of activities including Agro-ecosystem Analysis (AeSA), presentation and discussion in special topics, and group building activities. Groups are divided into five small teams and they spend one to two hours in the field making observation, counting population densities of different species, assessing crop physiological condition and recording observation. Each team in the field

school analyses and interprets the data and summarizes the result often in an agro-ecosystem diagram. These diagrams include a picture of the crop plant at the stage of growth of the crop for that week. Animals (pests that damage crop and may produce symptom) are drawn on the side of picture of the crop plant, while natural enemies that damage /eat such pests and thus protect the crop are drawn on the other side. As IPM is the knowledge intensive technology, it demands farmers greater degree of knowledge absorption and decision making abilities. Various studies indicated that about 35-40 % pre- and post-harvest losses are caused by pests (PPD and FAO, 2004.). Several types of chemicals are used to control disease and insect pests of the major crops in Nepal (Thapa, 1999). Chemical causes the long term effects such as effect in soil environment, human health, ground water contamination, pesticide resistance, pest resurgence and other ecological effect but these effects are being neglected by the farmers (Thapa and GC, 2000). Nepal has been following the IPM program in FFS model since 1998 (Upadhya, 2002; Lama, 2002). The field school approach seeks to replace top-down, input intensive technologies with knowledge intensive techniques. The methods, strategies, and techniques applied in FFS directly contrast with the pedagogic, diffusionist and top-down oriented extension methods (FAO, 1999). The learning models of farmer's field school were used in student field school, which is launched in the IAAS for the first time in academic level.

METHODOLOGY

The season long IPM field school was conducted in plant protection research farm of IAAS in bitter melon crop and Pusa variety. Thirty six participants including graduates, Lecturers, staffs were involved in the field school. The Master IPM facilitator from Government of Nepal facilitated the training session every Saturday, whereas in special cases, renowned scientists and experienced trainers were invited from different departments at IAAS. All crop protection and crop management practices were based on the outcome of the weekly Agro-ecosystem Analysis (AeSA), conducted by the field school participants.

Group formation

The group was divided into five subgroups and assigned collection of data with different aspects of cucurbits growing practices like cultural practices diseases and insect problems, input marketing, harvesting, post harvest practices and marketing etc to assess the real farmers' practices for growing cucurbit crops, which is incorporated at the time of field school experimentation. Whatever possible the male and female were distributed equally and group leaders were selected from each group. Each group was provided with a special assignment in each AeSA.

Preparatory meetings and field school start up

The formal program including with its objectives and some process activities of IPM like gender and social inclusion analysis, crop/variety selection, participant selection, preparation of cropping calendar site selection and experiment laid out, soil sampling, expectation matching and norms/ times setting were conducted accordingly in preparatory meeting. The field school were started with laid out designs, experiments, demonstration, field preparation, laid out activities were performed. The major activities are Mandatory and supportive trial, BBT (Pre test and Post test) Insect drawing, Life cycle and food web study, Comparisons on IPM and FFS, Pest monitoring etc.

IPM Vs Farmer Practice

Comparative study was done in total area 500m². 250m² area was allocated for each for IPM and Farmer's field. The basic components of cultivation practices were utilized to compare in the farmers and IPM practices (Table 1).

Table 1 Farmer's and IPM practices

Farmer's practice	IPM practice
Area: 250m ² Compost: 20 doko Variety: Pali Poultry manure; 1 ½ quintal Total plant: 123/250m ² Compost: Broadcasting Irrigation: Drip irrigation Seed distance: 2.25mx 50cm (5x2 hat) Chemical fertilizer: Urea: 1kg/250m ² DAP: 1kg/250m ² Potash: 1kg/250m ²	Area: 250 m ² Seed inside pit: 1feet Compost: 4.5 kg/plant Variety: Pali Poultry manure: 0.5 kg/plant Total plant: 166.67/250m ² Compost: Inside pit Irrigation: Drip irrigation Seed distance: 1 m x 1.5m Chemical fertilizer: Urea: 11g basal/10g top dressing DAP: 12gm basal Potash: 6 gm basal

Summary of major activities

AeSA was carried out on weekly basis. Agro-ecosystem means to observe the environment in and around the plant canopy. The environmental situation, germination percentage, plant height, leaf number, number of branches, male and female flowers, biotic populations on weekly basis. The intercultural operations along with weed management and yellow pan trap were set in the IPM field, whereas 24 DAS, staking Practices on IPM field were done. Contact and safe pesticides were sprayed depending on the insect and diseases infestation. 47 DAS, data of male and female flowers were taken

and fitted in the AeSA form. Food baits and cue lures are prepared and laid out in experimental field for monitoring of fruit fly. The locally available materials like Mustard Meal, Cellar dust, Bone meal, well decomposed FYM/Forest soil, Bheli, Cattle urine and EM were collected to prepare Bokasi mal and Jhol mol was prepared with collecting various botanical materials which were used in IPM plot. The major diseases appeared in different AeSA period were downy mildew, powdery mildew, wilting, leaf curl diseases and mosaic problems. The severity of Downey mildew was found higher at the time of low humidity and slight rainfall period. The fungus problem was minimized with the spray of Krinoxyl Gold (Fungicide) @ 5g/l of water. The problems of virus were minimized with mixing of cow milk with water at the ratio of 1:4.

RESULTS AND DISCUSSION

Germination and plant height

Germination % in IPM was found to be 71.33% which was comparatively lower than in Farmer's field (83.33%) the reason could be deep placement of seed whereas in farmers field farmers particularly sown the seed in surface which facilitate germination and proper growth and development. The plant grows its height with increasing days. The average growth of plant height was found higher in IPM field in comparison farmers managed field throughout the crop growing period (Figure 1).

Leaf and flowers numbers

The average leaf numbers in farmer and IPM fields were found more or less similar. However, more

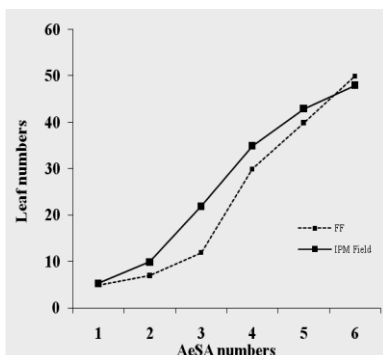


Fig. 2: Average leaf number in Farmer and IPM plots, IAAS Rampur, 2010

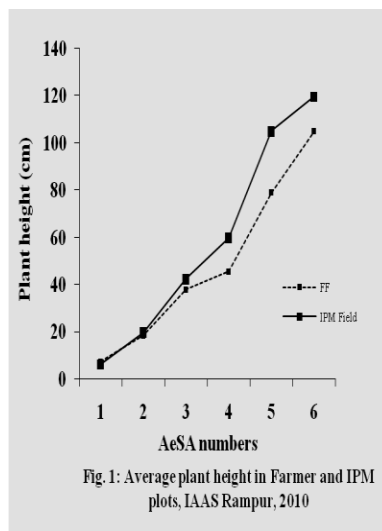


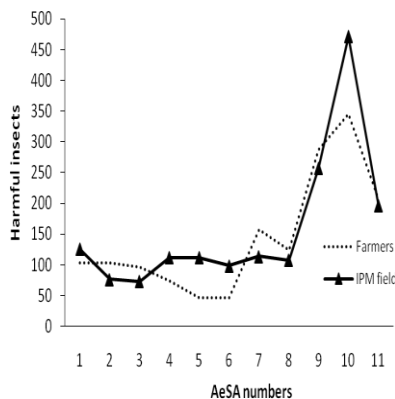
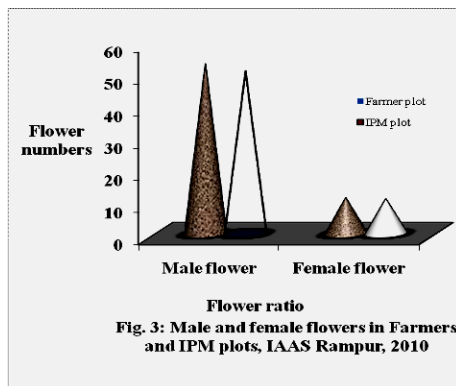
Fig. 1: Average plant height in Farmer and IPM plots, IAAS Rampur, 2010

number of leaves was found in IPM plot in comparisons to farmers managed plots (Figure 2). The tendency of increasing leaf numbers was increasing with respect to time. But the increasing rates were decreasing with the plant senescence.

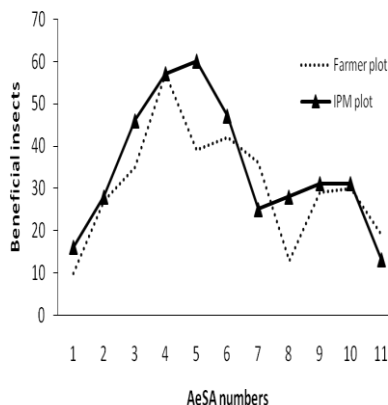
Flower

Male flower appeared earlier than the female flower in the early stage of plant development.

Then gradually the number of male and female flowers increased but female flower were always lower than male (Figure 3). At the fruit development stage female flowers decreased drastically as compared to the male flowers. The ratio of male and female flowers were found maximum during full vegetative stage and gradually decreased with increasing the vegetative stages.



Insect activity: The ratio of harmful and beneficial insect in farmer's plot was found in the ratio of 1:5 and 1:4 in IPM plot. This may be because of luxurious growth in IPM field. The number of insect activity slightly increases up to 8th AeSA in both plots and maximum number of insect reached at 10 AeSA periods in both plots where the maximum vegetative growth of plant attained. Comparatively the number of insect was found higher in IPM plot in comparison to farmers plot to all growing period of plants.



The more severity of the insect pests and the diseases in the IPM field might be due to the tenderness of the fruits and leaf portion, highly dense canopy of the plants which facilitates the habitats of the many species of the insects and high nutrient status of the plants, whereas the pattern of beneficial insect was recorded erratic trend in both the plots.

The number of beneficial insects increased up to 6th AeSA and then gradually reduced with increasing AeSA number. However, more number of beneficial insects was recorded in IPM plot than Farmers managed plot. Moreover,

when comparing the predator and prey relationship, more number of aphid populations was recorded in farmers plot. That may be because of insect resistance with frequent use of pesticides and high percentage of succulence in the plant. Whereas the aphid and lady bird population was found greater in IPM plot.

Fruit fly monitoring: Monitoring of fruit fly with cue lure indicates that the trend of fruit fly trapping was increased with increased the AeSA number. Maximum number of fruit fly trapping was recorded at 7th to 8th AeSA period and after that the number was reduced drastically. The maximum number of insect might be due to the coincidence with the adult emergence and favorable climatic situation.

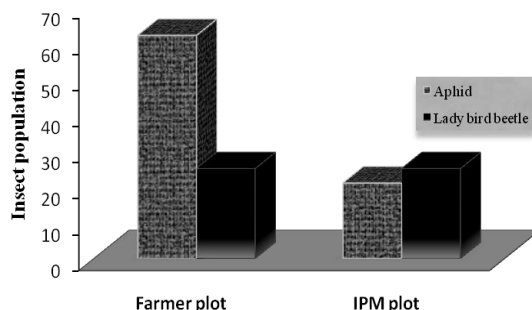


Fig.6 Aphid and Lady bird beetle population, IAAS Rampur, 2010

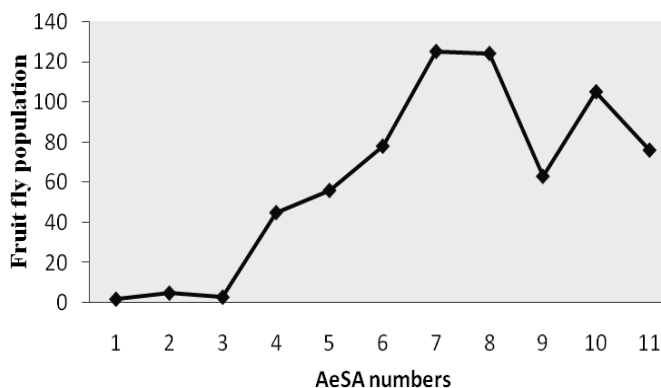


Fig. 7 No of fruit fly trapped in cue lure trap, IAAS Rampur, 2010

Yield status: While comparing the yield between IPM and farmers field it was observed that total yield obtained in IPM was much higher (336.83 kg) than in farmer's field (211.50 kg). The integrated and judicious use of inputs facilitates more and healthy production. Whereas the blind approach of crop production techniques in farmers field induces lower yield and unsafe product. Instead of this in IPM plot, the crop protection measures were applied only after AeSA outcome.

CONCLUSION

Agro-ecosystem analysis, fundamental part of IPM led to critical analytical power for the decision making process. It is more economic, scientific and uses the indigenous knowledge of the farmers. The training provides technical knowledge and group dynamics activities in field school develop leadership and group working. Similarly, the trial and study provides knowledge about the general idea of research. The average growth status of vegetative stages of plants was greater in IPM field than in farmers managed field. The mobility of insect and diseases problem was found higher in early crop growth stages whereas insect mobility was lower in later crop stage in IPM plot but number of beneficial insects was found always higher in IPM plot. Moreover, the AeSA technique provides knowledge to the farmers about judicious and rational use of pesticides which always encourages the quality and safe environment and discourages dirty and unhealthy environment. Hence, IPM practice proved to be better in all the aspect as compared to Farmer's practice. IPM practice includes physical, biological, mechanical, cultural, chemical management of insect pest with least emphasis on chemical practices. Hence IPM practice should be recommended for healthy life and sustainable farming.

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Yield and Yield Attributes of Direct Seeded Upland Rice Varieties at Sundarbazar, Lamjung

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ABSTRACT

Rice (Oryza sativa L.) is the major cereal crop in Nepal. It ranks first in area along with production among all cereal crops of Nepal. The most of rice cultivation of Nepal are rainfed condition. The yield and yield attributes of direct seeded upland rice was evaluated at Sundarbazar VDC-8 of Lamjung district at farmers' field during 2006. Ten different varieties of rice were direct seeded and evaluated at rainfed situation. The design of experiment was RCBD. The plot size was of 7x3 m² with 4 replications. The yield attributes (panicle length, grains/panicle, number of filled grains/panicle, number of unfilled grains/panicle, thousand grain weights, biological yield and harvest index) were significantly different among the tested varieties. The highest grain yield was obtained in Ghaiya-2 (3.79 t/ ha), while highest straw yield was obtained in Param Puri (19.42 t/ha). Similarly, the lowest grain yield was recorded in Rato Kanake (2.263 t/ha) and the lowest straw yield was observed in Bindeshwori (8.153 t/ha).

Key Words: Upland rice, Rainfed, Harvest index, Yield

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of more than 60 % of the world's population. About 92 % of global rice is produced and consumed in Asian Region (Singh, 1997). Rice is most important crop of Nepal and ranks first crop for both acreage and production. In Nepal, agriculture sector contributes around 33.35% to the total GDP of which contribution of rice accounts 20% (AICC, 2011). Upland rice refers to rice grown on both flat and sloping fields that are not bunded and fields are prepared and seeded under dry conditions (De datta, 1975). Upland rice, known as *Ghaiya Dhan* in Nepali, is mainly grown in Tars, and in marginal hillside terraces. Tars are actually ancient alluvial fans now formed into flat basins with agricultural importance.

Upland rice growing farmers are facing many problems. Among the problems, drought is most common. Drought has been recognized as the primary constraint to rainfed rice

production. Yield losses caused by drought at the anthesis and seedling stages combined were about double than caused by weeds (Hsaio, 1982).

Most of the areas in Sundarbazar VDC of Lamjung district are rainfed. This implies the farmers to depend on rainfall for the cultivation direct seeded upland rice and they use local cultivars which give lower yield. So, this study was designed and implemented with the aim of introducing the suitable rainfed rice varieties and evaluate them for yield attributes.

MATERIALS AND METHODS

The experimental carried out in Randomized Complete Block Design (RCBD) with 10 treatments and four replications (40 plots) with plot size of 7x3 m². The spacing was maintained at 20 cm x 20 cm. fifteen plants were used for the measurement of yield attributes. The number of effective tillers/m², panicle length was taken just before harvesting and mean were calculated. Number of filled and unfilled grains was also counted to determine the number grains per panicle. Thousand grains were counted from the grain yield of net plot and weighed with the help of portable automatic electronic balance. Finally grain yield was adjusted at 12% moisture using the formula as suggested by Paudel (1995).

$$\text{Gain yield (kg/ha) at 12\% moisture} = \frac{(100-\text{MC}) \times \text{Plot yield (kg)} \times 10000(\text{m}^2)}{(100-12) \times \text{net plot area (m}^2\text{)}}$$

Where, MC is the moisture content in percentage of the grains.

Straw yield were taken from net plot. The biological yield was calculated by using following formula.

Biological yield = Grain yield + straw yield

Harvest index (HI) was computed with formula.

H.I. % = (grain yield × 100)/ (grain yield + straw yield)

The data were analyzed by using MSTAT-C Micro Computer Programs (1990).

RESULTS AND DISCUSSION

Panicle length

Among yield components, length of panicle is also an important component. There was statistically significant difference in panicle length (Table 1). The highest panicle length was found in Rato Kanake (24.74 cm) and the lowest in Bindeshwari (18.94 cm). In case of improved varieties, IR 55435-5 was recorded for higher panicle length (20.98 cm). Bhurer and Gharti (2003) reported 22.7 cm panicle length of Ghaiya-2 at Bardia

condition. Table 1 indicated that length of panicles in local races were higher than the improved varieties. Therefore, these local varieties were called panicle weight type varieties. There was highly significant correlation ($r=0.872^{**}$) between panicle length and plant height.

Effective tillers/m²

Effective tillers/m² was found significantly different in between improved and local varieties (Table 1). It ranged from 266.5/m² (Bindeshwari) followed by Radha-32 (247.5/m²) and Ghaiya-2 (232.8/m²), whereas the lowest tillers /m² was observed in Tauli (163.3/m²), Chiuri (168.8/m²) and Rato Kanake (97.50/m²). The total tillers/m² was also found significantly different among the tested varieties. The maximum number of total tillers/m² was recorded for variety Bindeshwari (270.3) followed by Radha-32 (266.8) while minimum number of total tillers/m² was recorded in local variety Rato Kanake (102.0). This finding was in the line of Sah *et al.*, (2000) where they reported that highest number of effective tillers/m² was found in improved variety than local varieties.

Thousand grains weight (g)

Table 1 showed that there was significant difference in thousand grain weight among the tested varieties. The maximum thousand grain weight was obtained in IR 55435-5 (27.8 g) followed by Ghaiya-2 (24.15 g), Bandana (23.25 g) and minimum in Bindeshwari (19.85 g). Similar type of findings was reported by Bhurer and Gharti (2003) Bardia condition.

Grains/panicle

The total number of grains/panicle, number of filled and unfilled grains/panicle from fifteen randomly selected panicle of each plot was used for counting. The total number of grains/panicle was statistically significant (at 5% level) among the tested varieties. The maximum number of grains/panicle was counted in Rato Kanake (179) followed by Chiuri (168) and Pakhe jhinuwa (166) and the minimum were obtained from Bindeshwari variety (Table 1). The number of filled grains/panicle was also found significantly different among the tested varieties. The maximum filled grains/panicle recorded from Rato Kanake (172.3) and minimum was obtained from variety Bindeshwari (70.00). Similarly, the number of unfilled grains/panicle was also found significantly different in different rice varieties. It ranged from 2.750 (Bindeshwari) to 10.25 (Bandana and Tauli). Sah, et al. (2000) also found the highest grains/panicle in local varieties than improved one. The maximum number of grains/panicle was obtained in most of the local varieties as compared to improved varieties. However, the grain yields of local varieties were obtained lesser as compared to improved varieties and that might be due to less number of tillers/unit areas.

Table 1 Yield attributes of direct seeded different upland rice varieties

Treat. No.	Variety	Total tillers/ m ²	No. of effective tillers/ m ²	Panicle length (cm)	No. of filled grains/ panicle	No. of unfilled grains/ panicle	Total grains/ panicle	Test weight (g)
1	IR 55435-5	226.8 _{abc}	199.3 ^{bc}	20.98 ^{cd}	81.75 _{de}	9.500 ^a	91.00 _{cd}	27.80 _a
2	Ghaiya-2	236.8 _{ab}	232.8 ^{ab}	19.14 ^{de}	80.25 _{de}	4.500 ^{bc}	84.75 ^d	24.15 _b
3	Radha-32	266.8 _{a†}	247.5 ^a	20.38 ^{cde}	75.50 ^e	4.500 ^{bc}	80.00 ^d	21.15 _{cd}
4	Pakhe jhinuwa	203.5 _{bc}	185.8 ^c	23.21 ^{ab}	155.8 _{ab}	10.00 ^a	166.0 ^a	20.80 _{cd}
5	Bandana	204.5 _{bc}	195.3 ^{bc}	20.53 ^{cde}	112.8 _{cd}	10.25 ^a	125.5 _{bc}	23.25 _b
6	Bindeshwori	270.3 _a	266.5 ^a	18.94 ^e	70.00 ^e	2.750 ^c	72.75 ^d	19.85 _d
7	Parampyuri	178.0 _c	162.8 ^c	23.21 ^{ab}	124.0 _{bc}	4.500 ^{bc}	128.8 ^b	21.15 _{cd}
8	Chiuri	189.5 _{bc}	168.8 ^c	23.61 ^a	159.0 _{ab}	8.250 ^a	167.5 ^a	21.38 _c
9	Tauli	176.5 _c	163.3 ^c	21.56 ^{bc}	116.5 _{cd}	10.25 ^a	126.3 _{bc}	23.30 _b
10	Rato Kanake	102.0 _d	97.50 ^d	24.74 ^a	172.3 ^a	7.000 ^{ab}	179.0 ^a	21.67 _c
S.E		15.41	14.35	0.6012	11.65	1.099	11.89	0.4390
LSD (0.05)		44.73	41.63	1.745	33.79	3.190	34.51	1.274
CV %		15.01	14.95	5.56	20.29	30.75	19.47	3.91

† Figure in column with the same letter are not significantly different (p=0.05) according to Duncan's Multiple Range Test, S.E= standard error of mean difference, LSD= least significant difference, CV= coefficient of variation

Grain yield

The grain yield of different varieties was presented in Table 2. The data pertaining to the grain yield of different varieties showed that all the varieties had significant differences at 5% level. The maximum grain yield (3.79 t/ha) was obtained in Ghaiya-2 followed by IR 55435-5 (3.69 t/ha), Radha-32 (3.48 t/ha), and the minimum in variety Rato Kanake (2.26 t/ha) (Figure 1). However, the yields of improved varieties namely Ghaiya-2 (3.79

t/ha), IR- 55435-5 (3.69 t/ha), Radha-32 (3.48 t/ha), Bandana (3.42 t/ha) and local check Pakhe jhinuwa (3.28 t/ha) was found to be statistically at par. Bhurer and Gharti (2003) also observed highest grain yield of variety Ghaiya-2 at Bardia condition.

The grain yield was not satisfactory in case of local varieties except Pakhe jhinuwa. Less number of tillers, poor grain setting and lodging could be the reasons for low yields of local varieties. Rats and birds damaged maximum number of plants and grains which caused the low production of grain in local varieties such as Chiuri, Tauli, Pakhe jhinuwa and Rato Kanake. This might be due to their attractive and drooping type of panicles, drooping flag leaf and lodging behavior.

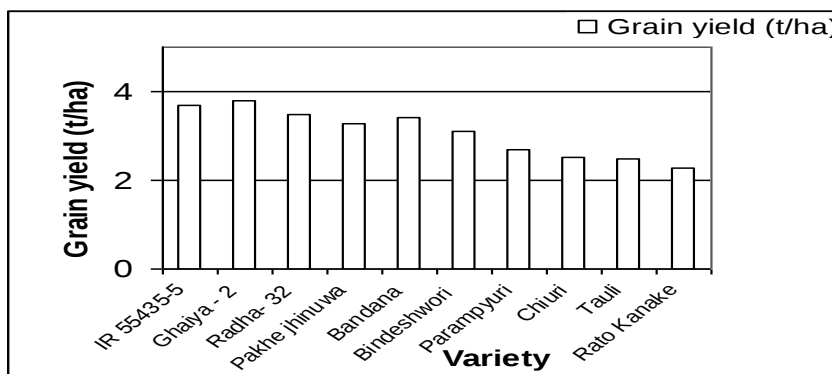


Figure 1 The grain yield of different varieties

Most of the improved varieties were semi dwarf and did not lodge. The damage of grains by birds was less in the varieties having erect flag leaf (IR 55435-5, Radha-32, Ghaiya-2) than the varieties with drooping flag leaves (Rato Kanake, Chiuri, Parampyuri). The weed infestation was also higher in local varieties than improved varieties. The major yield attributing characters viz: length of panicle, 1000 grain weight, number of filled grains/panicle and effective tillers/m² were also highest in improved varieties. The effective tillers/m² had significant correlation with grain yield ($r=0.733^*$). The contribution of grain yield by effective tiller/m² was found about 53%. The relationship between grain yield and effective tillers/m² of direct seeded upland rice is presented below (Figure 2).

Straw yield

Straw yield of tested varieties was also significantly different (Table 2). The maximum fresh straw yield was obtained from the local variety Parampyuri (19.42 t/ha) followed by Chiuri (19.40 t/ha) and Pakhe jhinuwa (19.12 t/ha). The straw yield of varieties IR 55435-5, Ghaiya-2 and Bandana were found statistically at par. All the local varieties were found to be taller than improved varieties which could be the reason of higher straw

yield compared with improved ones. Subedi (2006) also found higher straw yield in local cultivars than the improved varieties. There was significant correlation ($r=0.756^*$) between plant height and straw yield.

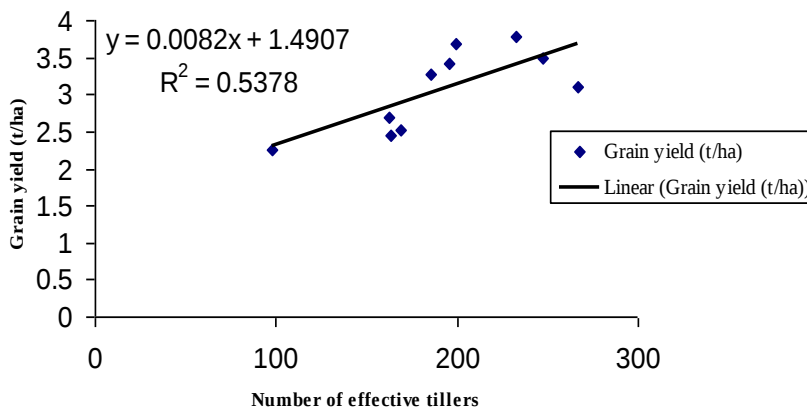


Figure 2 Relationship between grain yield and effective tillers/m² of direct seeded upland rice

Biological yield

Biological yield of direct seeded upland rice cultivar was recorded significantly different among the tested varieties (Table 2). It ranged from 22.40 t/ha (Pakhe jhinuwa) to 11.26 t/ha (Bindeshwari). The Biological yield of varieties IR 55435-5(14.92 t/ha), Radha-32(16.61 t/ha), Tauli (15.92 t/ha) and Rato Kanake (17.73 t/ha) were found to be statistically at par. The local cultivars were found higher biological yield as compared to improved varieties. This was due to higher fresh straw yield of local cultivars than improved varieties.

Harvest index

Table 2 indicated that the harvest index was significantly different among the tested varieties. The highest harvest index was found in variety Bindeshwari (0.276) followed by Ghaiya-2 (0.265) and IR 55435-5 (0.247). The lowest harvest index was found in variety Chiuri (0.117) followed by Param pyuri (0.122). The harvest index of varieties Pakhe jhinuwa, Parampyuri, Chiuri, Tauli and Rato Kanake were found statistically at par. The harvest index was found higher in improved varieties than local varieties.

Table 2 Mean grain yield and straw yield, biological yield and harvest index of different varieties

Treatment No.	Variety	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index
1	IR 55435-5	3.690 ^{af}	11.23 ^{cd}	14.92 ^b	0.247 ^{ab}
2	Ghaiya-2	3.790 ^a	10.49 ^{cd}	14.28 ^{bc}	0.265 ^a
3	Radha-32	3.483 ^{ab}	13.13 ^{bc}	16.61 ^b	0.207 ^b
4	Pakhe jhinuwa	3.280 ^{abc}	19.12 ^a	22.40 ^a	0.145 ^c
5	Bandana	3.420 ^{abc}	10.90 ^{cd}	14.32 ^{bc}	0.239 ^{ab}
6	Bindeshwori	3.112 ^{abcd}	8.153 ^d	11.26 ^c	0.276 ^a
7	Parampyuri	2.703 ^{bcd}	19.42 ^a	22.13 ^a	0.122 ^c
8	Chiuri	2.523 ^{cd}	19.40 ^a	21.92 ^a	0.117 ^c
9	Tauli	2.477 ^{cd}	13.44 ^{bc}	15.92 ^b	0.156 ^c
10	Rato Kanake	2.263 ^d	15.46 ^b	17.73 ^b	0.131 ^c
S.E mean		0.291	1.115	1.153	0.015
LSD (0.05)		0.845	3.235	3.345	0.045
CV %		18.93	15.84	13.44	16.57

† Figure in column with the same letter are not significantly different ($p=0.05$) according to Duncan's Multiple Range Test, S.E- standard error of mean difference, LSD- least significant difference, CV- coefficient of variation

CONCLUSION

Based on results of the experiments it can be concluded that the varieties namely Ghaiya-2, IR 55435-5 and Radha-32 were the promising varieties for rainfed condition. However, it is suggested that this type of experiment needs to be conducted at least for two years for the validation of the tested varieties.

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Comparision of Growth Performance of Khari Goats Fed with *Ficus Lacor*, *Shorea Robusta* and *Castanopsis Indica*

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ABSTRACT

This study was conducted with the objectives to explore the potential level of inclusion of Sal (Shorea robusta) and Katush (Castanopsis indica) in goat feeding; and to compare the growth performance of Khari goats fed with Kavro (Ficus lacor), Sal (Shorea robusta) and Katush (Castanopsis indica). This experiment was carried out on female goats at Goat Research Station, Bandipur, from 9 Apr to 6 July, 2010. Sixteen female Khari goats of 6.66 months of age and similar body weight were divided into four groups having four animals in each group by using complete randomized design (CRD). Four types of diets were prepared for experimental animals. The animals of control (Treatment 1) group received Kavro adlib plus concentrate mixture @ of 1% of body weight. Treatment 2 was provided Sal adlib plus concentrate mixture @ of 1% of body weight. Treatment 3 got Katush adlib plus concentrates mixture @ of 1% of body weight, and Treatment 4, Sal and Katush adlib (in the ratio of 50:50) plus concentrates mixture @ of 1% of body weight. This study revealed that there was highly significant ($P < 0.001$) effect of feed and total dry matter intake (DMI) among diet groups. Highest final body weight gain was observed in Treatment 1 (14.45 ± 0.88 kg) followed by Treatment 2 and 4 (13.87 ± 0.47 and 13.52 ± 1.49 kg, respectively) that was significant ($P < 0.05$) among diet groups. Highest weight gain during 90 days of trial period was observed in Treatment 1 (4.07 ± 0.15) followed by Treatment 2 and 4 (3.62 ± 0.75 and 3.45 ± 0.70 kg, respectively) that was highly significant ($P < 0.001$) among diet groups. Average daily gain (ADG) was recorded highest in Treatment 1 (45.22 g/day) followed by Treatment 2 and 4 (40.22 and 38.33 g/day). The least ADG was observed in Treatment 3 (12.22 g/day).

Key words: Feeding trail, Feed intake, Body weight gain

INTRODUCTION

Goat plays a crucial role in household economy of the Nepalese farmers which ranks to second among the different livestock species for meat production and shares the second highest proportion on livestock Gross Domestic Products (GDP) of the country through meat (Gatenby *et al*, 1990). The Agriculture Prospective Plan (APP, 1995) of Nepal has given much emphasis to develop livestock sector and has envisaged uplifting the share of

livestock sector in agricultural GDP by 45% at the end of the plan period from current stage of 31%. The goat population of Nepal is estimated to be 8.47 millions of which 1.07 million (12.68%) were found in western hills (CBS 2008/09) that are producing 5007 Mt meat annually. Goat is one of the most important sources of income for the resource poor peoples in Nepal, and helps to generate the cash income needed for schooling their children, purchasing of food, clothes, medicine, social rituals and others.

In Nepal, there are more than 100 kinds of conventional fodder trees. Some of them are *Artocarpus lakoocha* (Badahar), *Bauhinia purperia* (Tanki), *Ficux roxburghii* (Nimaro), *Ficus semicordata* (Raikhanayo), *Ficus lacor* (Kavro). Fodder trees and shrubs have been used as animal feed during the winter when other fodder and forages get exhausted. Fodder trees and shrubs contribute 28% of the total supply of Total Digestible Nutrient (TDN). Fodder plants are grown on private lands or they are collected from the forest. The annual yield varies from 20 to 400 kg/tree, depending on species, locality, age, season, and method of lopping (Joshi, 1988; Tiwari *et al*, 2005).

Sal and Katush are the dominant non-conventional fodder tree species in the Terai, Bhabar, Siwalik Hills and Duns, and along the lower slopes of the middle hills in Nepal and occurs at elevations up to 1500 m above sea level (Shrestha, 1992). Fodder trees are being used for livestock feeding when other fodders are not available but their feeding technology is neither identified nor developed properly. Joshi and Singh (1990) have shown potentiality of these fodders in livestock feeding; and Subba (1998) has reported good digestibility and nutritive value of these fodders in ruminants.

In the mid hills, 50% of the total feed requirement comes from the farm, with the balance from stubble, forests, terrace risers and bunds. Feed shortage has been identified widely at the end of the dry season in March -June. During this season, farmers traditionally gather Sal, Katush, and other fodders in the form of leaves from community forests (Kiff *et al*, 1999). In other hand, participants of Regional Technical Working Group (RTWG) meeting of Western Development Region have been raising issues to explore the potential level of inclusion of Sal, Katush and other forest fodders in livestock feeding. Therefore, this study was initiated with the objectives to explore the level of inclusion of Sal and Katush in goat feeding; and to compare the growth performance of Khari goats fed with Kavro, Sal and Katush.

MATERIALS AND METHODS

Experimental animals: This experiment was carried out on young female goats at Goat Research Station, Bandipur, and Tanahun from 9 April to 6 July, 2010. Sixteen female Khari goats of average 6.66 months (5.56-13.2 months) of age and similar body weight (10 kg) were divided into four groups having four animals in each group by using Complete Randomized Design (CRD). They were drenched against internal parasites and vaccinated against infectious diseases and were kept in groups.

Experimental diet: The dry matter (DM) requirement of goats was calculated on the basis of 4 kg per 100 kg body weight. Following diets were formulated to the experimental animals (Table 1).

Table 1 Experimental diet of the animal

S/n	Treatment	Experimental diets
1	Treatment 1 (Control)	Kavro (adlib) + Concentrate mixture @ 1% of body weight
2	Treatment 2	Sal (adlib) + Concentrate mixture @ 1% of body weight
3	Treatment 3	Katush (adlib) + Concentrate mixture @ 1% of body weight
4	Treatment 4	Sal + Katus (50:50) + Concentrate mixture @ 1% of body weight

Feeding regime: The fodder was provided to the goats in group thrice a day (morning, afternoon and evening). Concentrate mixture made by Pancharatna Feed Industry, Chitawan was provided individually in plastic vessel once a day in the morning. Rate of concentrate mixture was corrected fortnightly according to the body weight. Quantity of fodder and concentrate mixture given daily to the goats weighed daily and refusal was weighed in next morning. Drinking water was provided thrice a day in adequate amount.

Chemical analysis: The samples of Kavro, Sal, Katush and concentrate mixture were sent to the Animal Nutrition Division, Khumaltar, Lalitpur for proximate and detergent analysis. The feed stuffs samples were dried to a constant weight under laboratory condition (Aman and Hesselmen, 1984) and were grinded approximately 2 mm size as per Wu et al. (1994) and Luharoo et al. (1996). Samples were subjected to laboratory analysis for proximate (AOAC, 1980) and detergent fiber components (Goering & Van Soest, 1967).

Measurement recording: The trial period consisted of 90 days after an adaptation period of 7 days. Total feed intake by the animals was recorded daily for the experimental period. The body weight gain of individual animal was taken at 15 days interval in the morning before feeding.

Data analysis: Obtained data were analyzed by using Statistical Package for Social Study (SPSS, 11.5 versions).

RESULTS AND DISCUSSION

RESULTS

Chemical composition of feed stuffs: The result of chemical analysis is given in Table 2.

Feed intake: Average daily intake of Kavro, Sal, Katush and concentrate mixture of experimental animals is given in Table 3.

Table 2 Chemical composition of different feedstuffs (% DM basis)

Ingredients	DM	OM	TA	CP	CF	EE	Ca	P
Kavro	32.63	88.64	11.36	10.54	20.24	NA	2.19	0.18
Sal	38.8	92.9	7.04	7.91	27.4	1.34	0.77	0.12
Katush	32.2	93.0	6.93	10.99	NA	NA	0.42	NA
Sal + Katush	40.6	92.8	7.2	8.93	NA	NA	0.41	NA
Concentrate mixture	85.9	88.8	11.13	16.13	11.49	NA	NA	NA

DM- dry matter, OM- organic matter, TA- total ash, CP- crude protein, CF- crude fibre, EE- ether extract, Ca- calcium, P- phosphorous

Table 3 Feed intakes of experimental animals (per day/animal)

Feed stuffs	(Mean $\pm$ SD)			
	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Kavro, kg	2.64 $\pm$ 0.79	0	0	0
Sal, kg	0	1.88 $\pm$ 0.53	0	0
Katush, kg	0	0	1.20 $\pm$ 0.28	0
Sal + Katush (50:50), kg	0	0	0	1.83 $\pm$ 0.6
Concentrate mixture, g	125.43 $\pm$ 20.25	117.42 $\pm$ 13.50	99.54 $\pm$ 12.85	114.04 $\pm$ 10.4
Total DMI / animal, kg	95.63 $\pm$ 17.4	68.82 $\pm$ 11.60	46.56 $\pm$ 11	65.64 $\pm$ 8.1
DMI /kg live weight gain, kg	23.49	19.01	42.32	19.02

Table 3 showed that highest consumption of fodder, concentrate mixture and total DMI was noted for Treatment 1 (2.64 $\pm$ 0.79 kg, 125.43 $\pm$ 20.25 g and 95.63 $\pm$ 17.40 kg, respectively) followed by Treatment 2 (1.88 $\pm$ 0.53kg, 117.42 $\pm$ 13.50 g and 68.82 $\pm$ 11.60 kg, respectively) and Treatment 4 (1.83 $\pm$ 0.56kg, 114.04 $\pm$ 10.38 g and 65.64 $\pm$ 8.92 kg, respectively). Similarly, the least consumption of fodder, concentrate mixture and total DMI was recorded for Treatment 3 (1.20 $\pm$ 0.28 kg, 99.54 $\pm$ 12.85 g and 46.56 $\pm$ 11.04 kg, respectively). The intake of fodder, concentrate mixture and total DMI of experimental animals were highly significant ($P < 0.001$) among diet groups. Highest consumption of dry matter per kg weight gain was observed for Treatment 3 (42.32 kg) followed by Treatment 1 (23.49 kg). The consumption of dry matter per kg weight was merely similar for Treatment 4 and 2 (19.02 and 19.01 kg, respectively).

Growth performance: The growth performance of experimental animals is given in Table 4 and Figure 1. Despite initial weight of experimental animals was almost similar 10 kg, the final body weight was noticed highest in Treatment 1 (14.45 $\pm$ 0.88 kg) followed by Treatment 2 and 4 (13.87 $\pm$ 0.47 and 13.52 $\pm$ 1.49 kg, respectively). The lowest body weight gain was monitored for Treatment 3 (11.12 $\pm$ 1.31 kg). The final body weight gain significantly ($P < 0.01$) differed among diet groups. Highest weight gain during 90 days of trial period was observed in Treatment 1 (4.07 $\pm$ 0.15) followed by Treatment 2 and 4 (3.62 $\pm$ 0.75 and 3.45 $\pm$ 0.70 kg, respectively) that was significant ($P < 0.05$) among diet groups. Similarly, average daily gain (ADG) was recorded highest in Treatment 1 (45.22g /day) followed by Treatment 2 and 4 (40.22 and 38.33 g /day). The lowest ADG was observed in Treatment 3 (12.22 g/day).

Table 4 Growth performance of goats

Parameter	(Mean $\pm$ SD)			
	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Initial Body weight, kg	10.37 $\pm$ 0.85	10.25 $\pm$ 0.64	10.02 $\pm$ 0.52	10.07 $\pm$ 0.86
Initial metabolic weight, kg	5.77	5.72	5.63	5.65
Final Body weight, kg	14.45 $\pm$ 0.88	13.87 $\pm$ 0.47	11.12 $\pm$ 1.31	13.52 $\pm$ 1.49
Final metabolic weight, kg	7.41	7.18	6.08	7.05
Total weight, gain, kg	4.07 $\pm$ 0.15	3.62 $\pm$ 0.75	1.10 $\pm$ 0.92	3.45 $\pm$ 0.70
Average daily gain, g	45.22	40.22	12.22	38.33

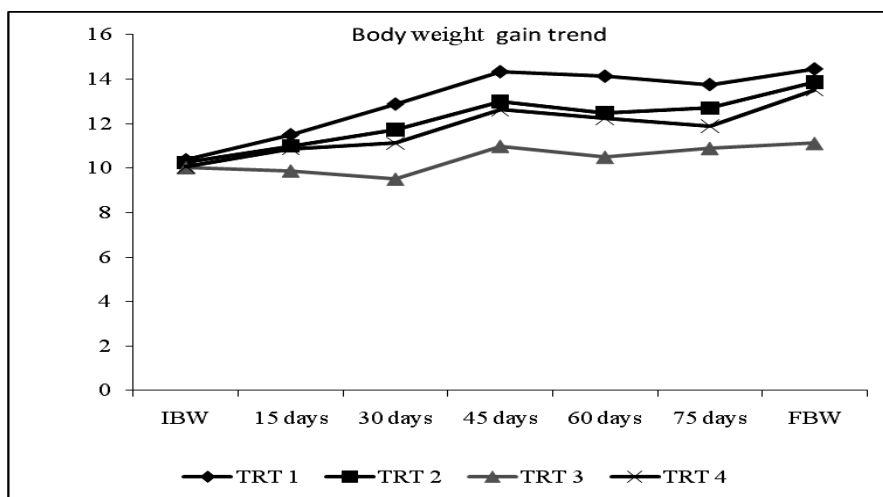


Figure 1 Body weight gain trend of goats during experimental period

DISCUSSION

The study revealed that experimental animals preferred Kavro (2.64 $\pm$ 0.79 kg /day/animal) followed by Sal (1.88 $\pm$ 0.53 kg day/animal) and Sal+ Katus mixed (1.83 $\pm$ 0.6 kg/day/animal). The experimental animals had given less choice to Katush sole (1.20 $\pm$ 0.28 kg/day/animal). Subsequently, it had resulted in increased total dry matter intake (DMI) 95.63 $\pm$ 17.4, 68.82 $\pm$ 11.60 and 65.64 $\pm$ 8.1kg for Treatment 1, 2 and 4, respectively. Both, fodder and total dry matter intake was found to be highly significant ($P < 0.001$) among diet groups. Likewise, study performed that animals fed with Katush (Treatment 3) consumed more dry matter (42.32 kg/kg weight gain) than Kavro (Treatment1), Sal (Treatment 2) and Sal+ Katush mixed (Treatment 4) fed diet group (23.49, 19.01 and 19.02 kg/kg weight gain, respectively).

The highest total weight gain of animals was recorded for animals fed with Kavro (Treatment 1) followed by Treatment 2 and 4 (4.07 $\pm$ 0.15, 3.62 $\pm$ 0.75 and 3.45 $\pm$ 0.70 kg,

respectively). The least body weight gain was recorded for Treatment 3 (1.10 ± 0.92 kg) which was highly significant ($P < 0.001$) among diet groups. Katush could not contribute higher total weight gain than Kavro though CP content of Katush was higher (10.99%) than Kavro (10.54%). It might be due to the low digestibility of CP available in Katush.

Kibria *et al* (1994) conducted an experiment where 28 Black Bengal goats were assigned to seven types of tree leaves: Mander (*Erythrina variegata* Lamk), Sal (*Shorea robusta* Gaertn.), Krishnachura (*Dolox regia* Boj ex-Hook), Jack fruit (*Artocarpus heterophyllus* Lamk), Ipil-ipil (*Leucaena leucocephala* Lam.), Mango (*Mangifera indica* L.) and Guava (*Psidium guajava* L.) reported that there were significant differences in dry matter intake between tree leaves. They suggested that tree leaves, such as Ipil-ipil, Jack fruit, Mander and Sal could be used as fodder for Black Bengal goats when 140 g concentrate mixtures were allowed for them.

CONCLUSION

This study revealed that conventional fodder (Kavro) performed better (4.07 kg) than non conventional fodders (Sal and Katus) in terms of total body weight gain (3.62 and 3.45 kg, respectively) during experiment period. Similarly, in case of potential level of inclusion, mixing of Sal and Katush in the ratio of 50:50 was found to be best combination to feed than to feed sole.

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Effect of Organic Nutrient Management on Growth, Yield and Soil Nutrient Status of Cabbage (*Brassica oleracea* var *capitata*)

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ABSTRACT

The study was conducted in the farmer's field at Balkot VDC of Bhaktapur district to find out the effect of organic nutrient management on growth, yield and nutrient status of cabbage. There were five treatments with different combination of organic manures. The plant height, breadth and number of leaves per plant were found highest with poultry manure application, whereas head weight and marketable yield were higher in the field where combination of farmyard manure and Vermicompost was applied. The higher amount of available soil nitrogen (N), Phosphorus (P) and Potassium (K) was observed under poultry manure application.

Key words: NPK, Poultry Manure, Vermicompost, FYM, Soil nutrient

INTRODUCTION

Cabbage (*Brassica oleracea* var *capitata*) is known to be the fresh vegetable. Brassicae vegetables are the most important vegetables in Nepalese diet and play an important role in the economy of the farmers (Timila et al., 2007). It is one of the important exportable vegetable crops produced in hills as well as in terai (Budathoki et al., 2001). It can withstand extreme cold and frost better than other vegetable crops. The growth in most of the cabbage varieties is arrested when temperature rises above 25°C. It can be cultivated in all types of fertile soils with good water regime (Chatterjee, 1999; Chadha, 2001). It has high nutrient requirement, particularly nitrogen, phosphorous, boron and molybdenum in the soil (Mengel & Kirkby, 1979). It does not grow well on a highly acidic soil but it is best grown above 6.5 pH. Higher acidity can be reduced by liming but it should not be raised beyond pH 6.5 (Chadha, 2001). It is one of the vegetables which could be supplied as off-season in the market during the hotter period (Pun & Karmacharya, 1988).

Organic farming is a production system, which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, and livestock feed additives. To the maximum extent feasible, organic farming system relies upon crop rotations, crop residues, animal manures, legumes, green manures, off- farm organic

wastes, mechanical cultivation, mineral- bearing rocks, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients, and to control insects, weeds, and other pests. The role of organic vegetable farming differs from green revolution not only technically but also in terms of socio-economic criteria such as crop affected beneficiaries, research requirement and local participation. In this approach, performance criteria include not only increased production but also the properties like sustainable food security, biological stability, biodiversity conservation and equity.

Majority of the cabbage growers in Nepal do not produce good quality head at a higher yield because of their lack of knowledge regarding proper use of organic and inorganic fertilizers. A crop production system having high yield targets cannot be sustainable unless nutrient inputs to soil are at least balanced against nutrients removal by crops (Bhuyan et al., 1991). However, limited information is available on organic nutrient management especially in Nepal. Therefore this study was conducted to indentify the effect of organic nutrient management on growth, yield of cabbage and the soil nutrient status of the field.

MATERIALS AND METHODS

The study was conducted from September to December 2010 on the farmer's field at Balkot, Bhaktapur district of Nepal. Experimental plot size was 2 × 2 square meter. The experiment was laid out in randomized block design with three replications and five treatments (Table 1).

Table 1 Treatments of experiment

Treatment	Manures
T ₁	Farm yard manure (FYM)
T ₂	Poultry manure
T ₃	FYM + Vermicompost
T ₄	Compost
T ₅	Control

The height of a plant was measured with the help of measuring tape from the bottom to the top of the plant at marketable stage. The number of leaves was recorded by counting the leaves per plant at the marketable stage. The cabbage heads were harvested at the time of marketable stage. After each harvest, the individual head was weighed and yield of cabbage was recorded from each individual plot.

Yield per plot: The observations on yield were recorded at the time of harvesting. After harvesting the heads from each plot were weighed and expressed in Kg.

Collection and preparation of soil samples: Soil sample representing 0-15 cm deep soil was collected from the experimental plot during the month of December. Three samples from each plot were taken and mixed to produce a composite sample. The soil sample

thus collected were dried in shade and sieved through 2mm 'Bronze' sieve and stored in cloth bags for analysis.

Available nitrogen was estimated by alkaline permanganate method as modified by Subbiah and Asiz (1956), available P was extracted with 0.5 N NaHCO₃ adjusted at pH 8.5 (Olsen et al., 1954) and determined by Phosphomolybdon blue color method (Dickman & Bray, 1940). Available potassium was determined by ammonium acetate method (Hanway & Heidal, 1952).

The statistical analysis of the data was carried out as per method described by Cochran & Cox (1963). The treatment effect was tested at 5 percent level of significance.

RESULTS AND DISCUSSION

Effect of organic manure on the growth of cabbage

Plant height: The maximum plant height (47.17cm) was observed in the treatment receiving poultry manure (Table 2). The better efficiency of organic manure in the treatment of poultry manure might be due to the fact that the organic manure would have provided the macronutrient and micronutrient in an optimum range to plant. The application of poultry manure would have helped in enhancing metabolic activity through the supply of micronutrient in the early growth phase which in turn has encouraged the overall growth.

Number of green leaves per plant: The maximum number of green leaves per plant (19.66) was observed in T₂ (Poultry manure). Which was statistically at par with T₁, T₃ and T₄ and minimum number of leaves (15.33) was in T₅ (control) (Table 2). The information clearly indicates that vegetative growth was higher in plots that received poultry manure.

Table 2 Effect of organic manure on the growth of cabbage

Treatment	Plant height (cm)	Number of leaves per plant
FYM	43.50	18.00
Poultry manure	47.17	19.66
FYM+V.C	45.66	17.66
Compost	44.50	17.00
Control	40.66	15.33
CD (0.05)	4.04	2.93
F	3.6313	2.8596

This might be due to the fact that application of poultry manure provides more nitrogen which is associated with high photosynthetic activity and vigorous vegetative growth.

Azad (2000) mentioned that the maximum number of leaves in cabbage plant was obtained when organic manures were used.

Effect of organic manure on the yield of cabbage

Head weight (kg/plant): The maximum head weight per plot (2.56 kg) was recorded with FYM applied in combination with Vermicompost, which were statistically at par with T₄ (Table 3). Organic manure plays a direct role in plant growth as a source of all necessary macro- and micro-nutrient in available forms during mineralization, improving the physical and physiological properties of soil (Kumar *et al.* 2009). It is an important source of nutrient for plant growth that needs to be maintained for agricultural sustainability. Nitrogen, phosphorus and potassium are the main elements which affect the growth of plant (Barooch and Ahmed 1983; Nurung 1980).

Yield per plot (kg/plot): The data pertaining to the effect of organic manures on the yield are presented in table 3. The maximum yield per plot was observed with treatment T₃ (20.07 kg), which was statistically at par with T₄. Minimum yield per plot was observed with T₅ (Table 3). The reasons of increased head yield per plant with the application of improved FYM and Vermicompost could be attributed to solubilization effect of plant nutrient by the addition of FYM and vermicopmost leading to increased uptake of NPK. The results are in agreement with the finding of Kumaran *et al.* (1998) who recorded an increase in head weight by the application of FYM and Vermicompost.

Table 3 Effect of organic manure on the yield of cabbage

Treatment	Head weight (kg/plant)	Yield per plot(kg/plot)	Yield per hectare (ton/ha)
FYM	2.23	17.15	43
Poultry manure	2.20	15.85	39
FYM+V.C	2.56	20.07	50
Compost	2.40	17.53	44
Control	1.87	14.60	37
CD (0.05)	0.29	2.78	6.60
F	8.5139	5.4096	5.75

Effect of organic manure on the soil nutrient status of cabbage field

Available nitrogen: The maximum available Nitrogen in soil was under poultry manure treatment (Table 4).

The applied poultry manure holds the nutrient and retains from losses. In spite of using chemical fertilizers, the nitrogen was found low in NPK treated soil, which might be due to leaching and volatilization loss. In the same way, mineralization of chemical fertilizers is faster than that of poultry manure. So the higher value of total nitrogen in poultry

manure treated soil is due to the slow but continuous release of nitrogen from poultry manure. Similar result was found by Tripathi *et al.* (1978).

Available phosphorus: The maximum available phosphorus in soil (84.35 kg/ha) was observed in T₂. This was statistically higher than in T₃ (75.97kg/ha), T₄ (73.40 kg/ha) and T₁ (71.78 kg/ha) . However, the minimum phosphorus was observed in T₅ (61.53 kg/ha) (Table 4). Phosphorus is the constituent of Adenosine Diphosphate (ADP) and Adenosine Triphosphate (ATP), which is absorbed by the plant in the form of H₂PO₄ at lower pH value and in the form of HPO₄⁻² at higher pH. The soil under the use of poultry manure release and retains the phosphorus due to enzymatic activity of microbial organisms. In this study, the magnitude of increase of available phosphorus was slight where combination treatments of organic manure were added. Similar results were reported by Rey et al. (2005).

Available potassium: The maximum K₂O content (195.07 kg/ha) was recorded in treatment T₂ (Poultry manure), which was not statistically at par to any treatment. However, the minimum potassium content (103.45 kg/ha) was recorded in T₅ (Table 4).

Table 4 Effect of organic manure on the soil nutrient status of cabbage field

Treatment	Available N (Kg/ ha)	Available P (Kg/ ha)	Available K (Kg/ ha)
FYM	258.31	71.78	138.00
Poultry manure	293.38	84.35	195.07
FYM+V.C	264.57	75.97	152.73
Compost	255.70	73.40	174.87
Control	239.00	61.53	103.45
CD (0.05)	19.36	16.12	14.83
F	10.4252	5.4348	55.5888

The parent material and use of organic manure affect the potassium content of the soil. The requirement of potassium content is quite essential for the proper growth and development of the crops. The crops which nutrients up take by roots form K⁺ in the soil. The Nepalese soil in average is rich in the content of available potassium (Jaishy et al., 2000). In this study, the potassium content was found higher in poultry manure treatment than other treatment. The available K₂O was found medium in treatment where organic manure was applied alone. Similar findings were reported by Rey et al. (2005).

CONCLUSION

According to this research the plant height and number of leaves per plant were found highest under the field where poultry manure was applied, whereas head weight and

marketable yield were found maximum in the field where combination of farmyard manure and Vermicompost was applied.

The available nitrogen (N), available phosphorus (P) and available potassium (K) content in the field was higher there, where poultry manure was applied.

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Relationships among Rotational Intensity, Crop Diversity Index, Land Utilization Index and Yield Efficiency in Bio-intensive and Conventional Farming Systems

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ABSTRACT

This study was conducted in Udayapur district in 2008. A questionnaire-based survey with 100 household heads along with field visit and personal interaction with the concerned farmers were conducted to gather required information. Data were analysed to compute Rotational intensity (RI), crop diversity index (CDI), land utilisation index (LUI), and yield efficiency (YE). Regression analyses were done to reveal relationships among these traits. BIFS farmers were found to practice scientific crop rotation substantially more than CFS farmers both in rice-based and maize-based cropping systems. In this study, higher RI, CDI, LUI and YE were found in bio-intensive farming system (BIFS) as compared to conventional farming system (CFS). The study has revealed strong positive relationship of RI with CDI and LUI in BIFS, CFS and in general. Cropping system both in BIFS and CFS with scientific crop rotation that ensures higher CDI and LUI is recommended for increasing yield efficiency. Direct positive relationship among RI, CDI and LUI has been revealed by this study as a rule and has suggested to be used in validating yield efficiency of optional farming system as compared to the mainstream conventional farming system.

Key words: Scientific crop rotation, Rotational Intensity (RI), Crop Diversity Index (CDI), Land Utilization Index (LUI), Yield Efficiency (YE), Regression analysis

INTRODUCTION

Proponents of Green Revolution or High Chemical Inputs Agriculture System (HCIAS) generally argue that developing countries should opt for an agro-industrial model that relies on standardized technologies and ever-increasing use of the chemical fertilizers and pesticides to provide additional food supplies for growing population. In contrast, a growing number of farmers, agro ecologists, NGOs and analysts propose that instead of the capital and petro-chemical input-intensive as well as environment-degrading approach, developing countries should favour an agro-ecological and socio-economic model (Altieri, M. A., P. Rosset, & L. A. Thrupp, 1998, Rajbhandari, 2000). Many of the techniques that comprise the biointensive method were present in the agriculture of the ancient Chinese, Greeks, Mayans, and of the Early Modern period in Europe. Alan

Chadwick brought together the Biodynamic and French intensive methods, as well as his own unique approach, to form what he called the Biodynamic-French Intensive method. The method was further developed by John Jeavons and Ecology Action into a sustainable 8-step food-raising method known as "GROW BIOINTENSIVE". Today bio-intensive farming is a system that emphasizes biodiversity, recycling of nutrients, synergy among crops, animals, soils, and other biological components, and regeneration and conservation of resources. In other words, the concept and approaches of BIF system is based on holistic system of sustainable management of natural resources in a given agro-ecosystem with specific cultural and knowledge base (Rajbhandari & Gautam, 1998). The principles of BIF system include scientific crop rotation; mixed farming systems; optimization of organic recycling; participatory and sustainable management of natural resources including biodiversity; participatory research and extension; and attainment of high degree of self-reliance of farm households against external techno-economic shocks (Rajbhandari, 2000). The bio-intensive approach is initially more labour-intensive than conventional approaches, and therefore best suited to small scale family centred food production in urban or rural settings (ILEIA, 1989). The bio-intensive farming system is a biologically intensive mixed farming system, which relies on intensive engagement of farmers, organic recycling optimization through intensive scientific crop rotations, integrated plant nutrient management (IPNM), integrated pest management (IPM). The bio-intensive farming system relies on appropriate spatial management of field crops, vegetable crops, fruits and fodder trees as well as livestock and poultry for rational and ecologically non-destructive utilization of lands. Furthermore, it increases the soil fertility, revitalizes the degraded soil, decreases environmental pollution and prevents health hazards to humans and livestock as well as reduces further degradation of the environment, which otherwise might lead to desertification of the globe. It is, therefore, not only eco-friendly but also friendly to human and animal health (Rajbhandari, 2010 b).

The technique behind adopting bio-intensive farming is that cropping systems and techniques specially tailored to the needs of specific agro-ecosystems are based on local inputs and techniques with each combination fitting to particular ecological resources by combining different components of the farming system (plants, animal, soil, water, climate and people) in order to optimize the synergistic interaction among the components (Rajbhandari, 2010 b). In this approach, performance criteria include not only increased production but also properties of sustainable food security, biological stability, resource conservation and equity (UNDP, 1995). However, there is not a single and simple method of validating efficiency of the alternate farming system like BIFS as compared to the mainstream conventional (petro-chemical based) farming system.

This study was conducted to estimate and analyze the relationships among rotational intensity, land utilization index, crop diversity index and yield efficiency, and find out the means of validating efficiency of optional farming system (bio-intensive farming) as compared to the mainstream conventional farming system.

MATERIALS AND METHODS

WOREC Nepal has been implementing bio-intensive farming system in Udayapur for the last 15 years; and therefore this district was selected as the study site. This study was conducted in 2008 covering four VDCs i.e. Rauta, Triveni, Hadiya and Jogidaha and one Triyuga municipality. Sample households were taken based on the farmer's engagement in bio-intensive farming system (BIFS) and conventional farming system (CFS). The total sample size was 100 households, i.e. 50 households from each system (10 households per VDC/municipality). Purposive random sampling technique was used to select the required number of households from both systems.

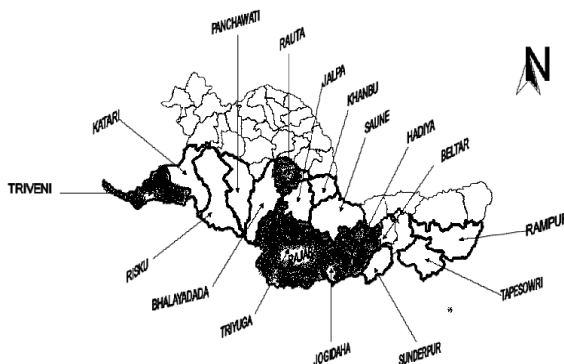


Figure 1 Map of Udayapur showing study areas (shaded areas)

The study was based on the primary data collected with the help of semi-structured questionnaire and published secondary information. The questionnaire was developed to gather relevant information required to meet the specific objectives. The questionnaire was first pre-tested with farmers for its accuracy and clarity. Then it was finalized by incorporating farmers' suggestions. The collected data were grouped, coded and entered into the computer for processing. Computer software MS excel was used to analyse the data. Mean value, standard deviation (SD) and R^2 were obtained to interpret the results. Similarly informations were also used to calculate Rotational Intensity (RI), Land utilization index (LUI), Crop diversity index (CDI), and Yield efficiency (YE). These were computed using the formulae given below. The number of crops grown in 5-year rotation, and respective areas and crop yields were taken into consideration. Regression plains were drawn and R^2 determined to estimate relationship between various parameters.

$$RI = \frac{\text{No. of crops grown in a rotation}}{\text{Duration of rotation}} \times 100$$

$$LUI = \sum_{i=1}^n a_i d_i / A \times 365$$

Where, a_i =Area occupied by i^{th} crop

d_i =days occupied by i^{th} crop

A =Total cultivated area available for 365 days (1 year)

n =Total number of crops grown per year

$$CDI = 1 - \frac{\sum x^2}{(\sum x)^2}$$

Where, x =Area under the individual crop

$$YE = Y_a / Y_l \times 100$$

Where, Y_a = Yield per unit area of the farm

Y_l =Yield per unit area of locality

RESULTS AND DISCUSSION

Scientific crop rotation

Scientific crop rotation is one of the important agro-techniques employed in order to reduce the pest incidence in the field as well as sustain crop yield. It was found that 68 percent of the BIFS adopting households followed the scientific crop rotation but in the case of CFS adopting households the case was just opposite. Sixty four percent of the households employing CFS had not followed scientific crop rotation (Figure 2). Those who did not followed the crop rotation usually used to grow the same vegetable (in the rice-based and maize-based cropping systems) in the same season, which actually provided ground for pest incidence.

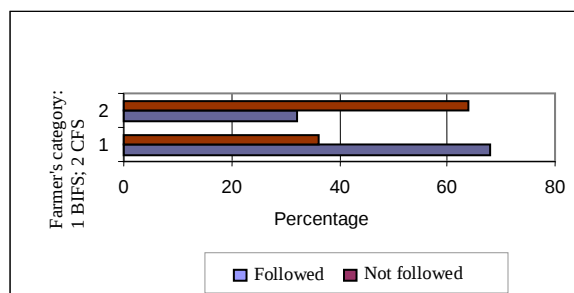


Figure 2 Practice of scientific crop rotation by the respondents (%)

Rotational intensity (RI), CDI, LUI and YE

Computed mean values and standard deviations of rotational intensity (RI), crop diversity index (CDI), land utilization index (LUI) and yield efficiency (YE) in bio-intensive farming system and conventional farming system are presented in Table 2.

Table 2 Mean values and SD of RI, CDI, LUI and YE in BIFS and CFS

Farming system		RI, %	CDI	LUI	YE, %
BIFS	Mean	440	0.70	0.91	123
	SD	54.77	0.054	0.035	12.29
CFS	Mean	260	0.44	0.65	84
	SD	54.77	0.051	0.055	11.00

It is evident from the table 2 that RI was only 260 percent in CFS, where farmers used to grow only 2-3 crops in the annual pattern, while in case of BIFS it was 440 percent. The BIFS adopting farmers used to grow 4 or more crops in the annual cropping pattern. Owing to higher RI the BIFS had higher CDI (0.70) than in CFS (0.44). Likewise, the BIFS had higher LUI (0.91) and YE (123%) as compared to the CFS (LUI = 0.65, YE = 84%). Rajbhandari (2010 a) and Duwal (2008) have shown that CDI and LUI have direct positive relationship with yield efficiency. BIFS farmers had higher return due to the higher RI, CDI and LUI. This clearly shows the supremacy of bio-intensive farming system based on integrated sustainable approach over conventional farming system in Udayapur.

Relationship among RI, CDI and LUI

Regression plains computed among various pairs of quantitative traits have revealed strong positive relationship of RI with CDI and LUI and that of CDI with LUI in general (in both systems together) and in both systems- BIFS and CFS- separately (Figure 3 to Figure 11). The computed value of R^2 in all pairs of traits in both systems combined (general) and separately was higher than 0.900.

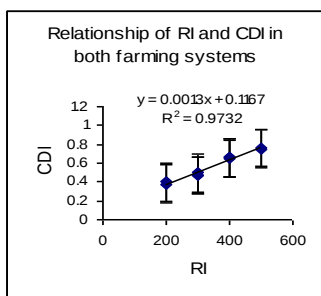


Figure3

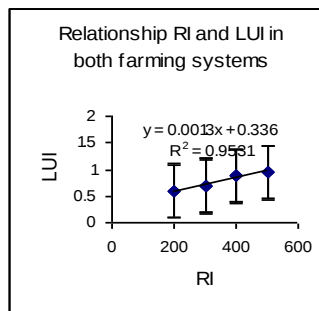


Figure 4

Figure 3 Relationship between RI & CDI in both farming systems combined

Figure 4 Relationship between RI & LUI in both farming systems combined

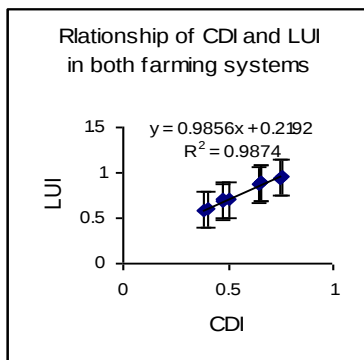


Figure 5

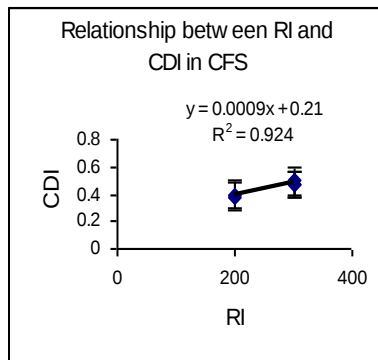


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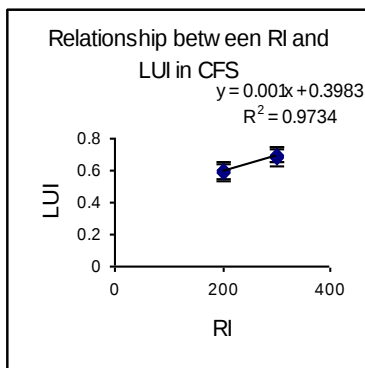


Figure 7

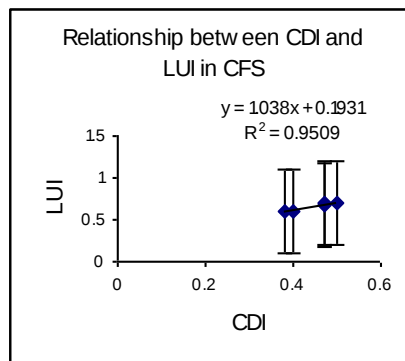


Figure 8

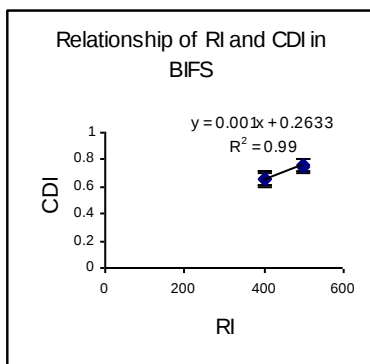


Figure 9

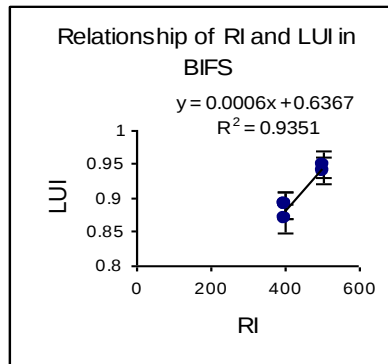


Figure 10

Figure 5 Relationship between LUI & CDI in both farming systems combined
Figure 6 Relationship between RI and CDI in CFS

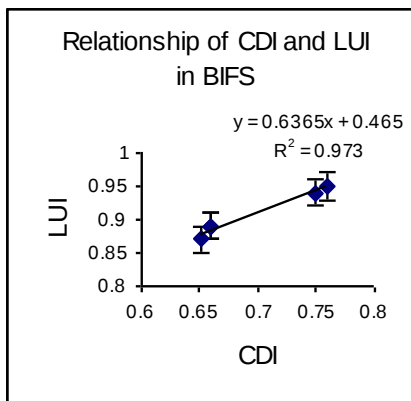


Figure 11

Figure 7 Relationship between RI and LUI in CFS

Figure 8 Relationship between LUI and CDI in CFS

Figure 9 Relationship between RI and CDI in BIFS

Figure 10 Relationship between RI and LUI in BIFS

Figure 11 Relationship between LUI and CDI in BIFS

Similar trends in the relationship among CDI, LUI and YE were reported by Rajbhandari (2010a). Positive relationship between cropping intensity and CDI was reported by Shahidullah et al (2006). The findings of this study were at par to those described by Rajbhandari (2010 a), Duwal (2008) and Shahidullah et al (2006).

Regression analysis has also revealed strong negative relationship of crop rotation and LUI with severity (incidence) of pest damage as reported by Duwal (2008) and Rajbhandari (2010 a). Obviously, in the CFS where rotational intensity and LUI is lower, the pest damage to yield is substantial. This is an important reason that yield has been declining in the farms where the use of only chemical fertilisers along with pesticides are continued without following scientific crop rotation. The farmers adopting BIFS have reported lesser incidence of crop damage by pests, and they have higher cropping intensity, CDI and YE (Duwal, 2008).

The RI, CDI and LUI had direct positive relationship in general (Figure 12) as well as in both farming systems separately (Figure 13 & 14). Thus direct positive relationship among RI, CDI and LUI has been revealed by this study as a rule that might be used in validating yield efficiency of optional agricultural system, eg BIFS as compared to the mainstream conventional agricultural system.

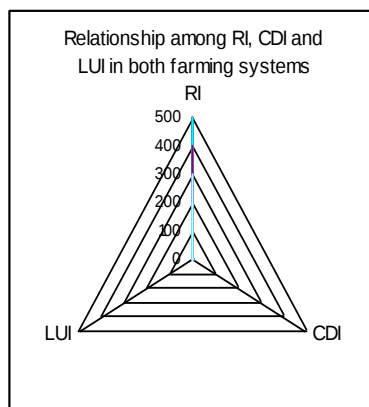


Figure 12

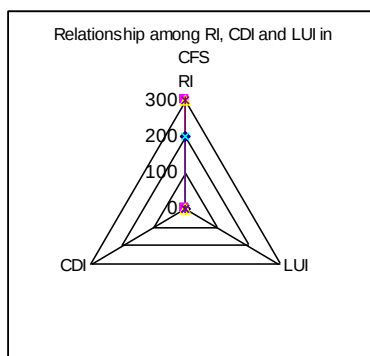


Figure 13

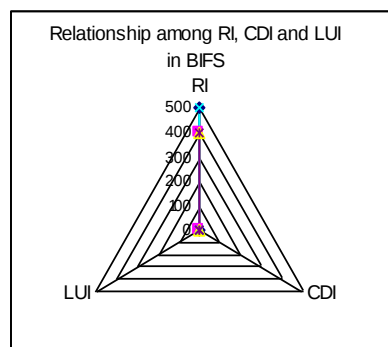


Figure 14

Figure 12 Relationships among RI, CDI & LUI in general (both farming systems combined)

Figure 13 Relationships among RI, CDI and LUI in CFS

Figure 14 Relationships among RI, CDI and LUI in BIFS

CONCLUSION

It is thus obvious from the findings that scientific crop rotation increases crop diversity and land utilization, and consequently the total crop yield in a given locality both under bio-intensive and conventional farming systems. Bio-intensive farming may be one of the best options to govern this relationship positively in favour of ecology and environment protection as well as food production and human health.

Direct positive relationship among RI, CDI and LUI has been revealed by this study as a rule that might be used in validating yield efficiency of optional agricultural system as compared to the mainstream conventional agricultural system.

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Integration of Groundnut (*Arachis hypogaea* L.) in the Western Hills of Nepal

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ABSTRACT

*With the aim of identifying and promoting suitable genotypes of groundnut, participatory research and promotional activities were conducted in three consecutive seasons of 2004-2006 under rainfed bariland (upland) condition in the mid hills of Nepal. Promising genotypes of groundnut (*Arachis hypogaea* L.) tested in the past was verified with or without seed inoculation by rhizobium and molybdenum in diamond trials with 2 X 2 factorial designs having 10 replications. The best genotypes were further promoted through larger plot demonstrations. Differences in pod yield and related attributes were significant due to the genotypes and seed inoculation with rhizobium and molybdenum. Irrespective of genotypes tested in groundnut, seed treated with rhizobium and molybdenum influenced significantly to produce the higher numbers of pods per plant, seeds per pod, shelling percentage, test weight, root nodules per plant and kernel yield except the test weight and plant population at harvest in both the years of 2005 and 2006. Yield increment due to seed inoculation over non inoculation was 29.5 and 5.94 kg in a 500 m² area from Jayanti and B-4 respectively under front line demonstration trial of groundnut. Partial budgeting revealed that the seed inoculated with rhizobium and molybdenum surpassed the net benefit as compared to non-inoculated in both the genotypes tested under front line demonstration during 2006. Jayanti was preferred by the farmers due to its' high and fertile kernel yield, high recovery rate over B-4. The technologies need to be further promoted through participatory research in the western hills of Nepal.*

Key words: *Arachis hypogaea* L., Participatory research, Rhizobium, Yield attributes, Net benefit.

INTRODUCTION

It has been realized that the productivity of maize based cropping system in *bari* land of western hills is either stable or reduced due to declining soil fertility. In the past, several technologies to improve the fertility status of soil have been recommended but very few of them are in reach of poor hill farmers. Among the various components of soil fertility legumes, if suitably inoculated, can fix 100 kg nitrogen per hectare to the soil (Khatri-Chhetri, 1991). Symbiotic nitrogen fixation, by legumes in association with the specific rhizobia, needs no emphasis. So due to higher nitrogen fixation rates by legumes these

crops need to be grown on as large acreage as possible. Grain legumes are dual purpose crops as these not only produce protein-rich grains but also fix considerable amount of nitrogen in the soil. Soybean increased yield of the following maize and most of the increase was due to their nitrogen contribution (Baldock et al., 1981). Where no N fertilizer was used, maize yields on lands which had previously grown winged bean (*Psophocarpus tetragonobus*) were 52-92% higher than those where maize was the previous crop (Weil & Samaranayaka, 1991) and the apparent nitrogen contribution by winged bean was found to be 70 kg N/ha. Inclusion of legumes in the cropping system is very important not only from the view point of nitrogen fixation but judicious utilization of soil -N also. As nitrate can sometimes leach below the reach of grain crop roots and if a deep rooted legume (e.g. alfalfa) is sown in the following season its roots can reach down and take up these nitrates, thereby preventing wastage and pollution of groundwater (Rohweder et al. 1977). In case the field lacks rhizobia, prior to sowing, legumes seeds need to be inoculated with specific Rhizobium culture to ensure effective nodulation and higher rates of nitrogen fixation. An experiment conducted by Fischer and Herridge (2008) in Vietnam have shown that fertilizer N input could be reduced to basal dose (i.e < 10 kg N/ha) replaced by inoculation in legumes. Similarly the profitability was increased by upto Aus \$ 760/ha through inoculation and reduction of fertilizer N inputs from high levels (30-150kg N/ha) down to less than 10 kg N/ha. Among the grain legume species groundnut is one of the potential catch as well as cash crops in the mid hills of Nepal. None of the improved genotypes released so far in Nepal were in reach of the remote hill farmers that too of Myagdi. This experiment was therefore conducted with the following objectives: i. to verify the promising varieties of groundnut for the bariland cropping system; and ii. to promote the verified technologies of groundnut for the upland cropping system.

MATERIALS AND METHODS

Based on the feedback received from the farmers through various formal and informal tools, following methodologies were developed and implemented in the farmers fields of western hills of Nepal. The promising varieties of groundnut suitable for bariland cropping system identified in the past through various participatory researches were verified as diamond trial in the field of 10 leader farmers with 7 groups in 5 different Village Development Committees (VDCs) of Myagdi in 2005 and 2006.

Experimentation of diamond and front line demonstration

Two varieties comprising improved (V1) and local i.e. farmer's variety (V2) of groundnut with two treatments comprising seed treated with Rhizobium and Molybdenum (T1) and untreated (T2) were tested in a single farm that enabled farmer to compare it with his/her own variety and management conditions. The plot size was 250 m² with the spacing 40cm between rows and 15cm between plants. Two plants in a hill were maintained while thinning out the seedlings. Procedure of seed treatment /inoculation with rhizobium and molybdenum is given below. Recommended doses of fertilizers was applied at the rate of

20:40:20 kg NPK/ha. All variables (husbandry practices) other than those being examined follow the farmer's normal management practices. A total of 10 diamond trials were conducted during last week of April with one farm representing one replication. During 2006, the best variety Jayanti of groundnut was demonstrated in a 500 m² plot with or without seed inoculation under front line demonstration. Site and farmers selection and group formation was done in collaboration with the District Agricultural Development Office (DADO), Myagdi. A meeting of concerned stakeholders was organized to formulate the plan. Seed was collected from the concerned commodity programs and rhizobium inoculums from soil science division, NARC. Benchmark soil samples were collected during the land preparation from the experimental and individual plot. Similarly, the final sample was collected immediately at the time of crop harvest from each treatment plot and was analyzed by specific methods at Lumle's soil laboratory. Five random sample spots for each treatment plots from the depth of 15 cm were collected and prepared for major soil nutrient and pH analysis at soil laboratory of RARS, Lumle. Determination of pH was done by pH meter (1:2.5 soil water), analysis of nitrogen was done by wet digestion and spectrophotometric determination method, available phosphorus was analyzed by Bray and Kurtz method, available potassium was analyzed by using 1M ammonium acetate extraction and was determined by Flame photometer and organic carbon was determined by Walkey-Black method. The number of pods/plant and kernels/pod, shelling percentage, 100 kernel weight (g) and average kernel yield kg/ha were recorded. Shelling percentage (SP) was calculated as $SP = \text{weight of kernels/weight of pods} \times 100$. Nodule population (pink coloured) was recorded from hypocotyls and stem during the pod filling stage. An activity protocol was adopted during the implementation of research. Farmer's feedbacks were also recorded along with experimentation.

Procedure adopted for inoculation of seed with rhizobium and molybdenum:

- Two teaspoonful of sugar was mixed and stirred well in a half glass of boiled water to prepare the slurry and kept until it was chilled.
- Mixed the required amount of seed in chilled water.
- Five gram of rhizobium culture was mixed in a kg of seed so that the inoculum was adhered perfectly on the seed coat.
- The treated seed was kept under shade for at least 10 minutes and then planted in the field. Molybdenum (5 gram/kg seed) in the form of Ammonium molybdate ($(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 2\text{H}_2\text{O}$) with 54% Molybdenum was also used to treat the groundnut seed.

RESULTS AND DISCUSSION

Yields attributes and yield of groundnut

Number of plants per m²: Variation due to groundnut genotypes with or without seed inoculation by rhizobium and molybdenum on plant stand was not significant in both the

years of 2005 and 2006. Combined analysis over the years also revealed that the difference in plant population was not significant. It might be due to the quality of seed, uniform emergence and establishment of seedlings (Table 1, 2 and 3).

Number of pods per plant: Differences in number of functional pods per plant were significant due to the treatment in both the years. Variation was distinct not only due to the genotypes but also seed inoculation in both the years. The highest number of pods per plant was recorded under the treatment combination of genotype Jayanti and seed inoculation with rhizobium in both the years. Similarly, the interaction effect of treatment and year for the trait was evident. It might be due to the better crop season during the second year of planting (Table 1, 2 and 3).

Number of seeds per pod: Significant variation among the tested treatment combinations in producing the seeds was observed in both the years of 2005 and 2006. Effect was distinct not only because of the genotypes but also seed inoculation in both the years. The highest number of seeds per pod was recorded in the treatment combination of genotype Jayanti and seed inoculation with rhizobium and molybdenum in both the years. Similarly, the interaction effect of treatment and year for the trait was evident. It might be due to the better crop season during the second year of planting resulted the higher seed yield (Table 1, 2 and 3).

Shelling percentage: The result showed significant differences among the treatments under consideration in case of shelling recovery in both years of experimentation. It indicates that the genotypes and the seed treatment with rhizobium have positive effect in the shelling percentage over the years. Similarly, highest shelling recovery was found in treatment combination of genotype B-4 and seed inoculation with rhizobium and molybdenum during both years. The result further revealed that the interactive effect of the treatment and year over the attribute was also evident. It might also be due to the bulky grains consequently the higher test weight of the B -4 as compared to Jayanti (Table 1, 2 and 3).

Test weight: Significant variation among the treatments was not observed for seed weight in both the years. Irrespective of seed inoculation, effect of genotypes on test weight of groundnut was evident in both the years. Genotype B-4 with seed inoculation surpassed the bulkiness of seed over the Jayanti having seed inoculated. Influence of year and treatment on this trait was also not evident. Since, the trait is more governed by gene rather than seed inoculation (Table 1, 2 and 3).

Pod yield: Grain yield of groundnut varied significantly due to the treatment effects in both the years. Irrespective of seed inoculation, Jayanti out yielded the B-4 in both the years. Similarly, irrespective of the genotypes, seed inoculated with rhizobium and molybdenum influenced the pod yield for both the years. Mean grain yield of groundnut was 2057.13 kg/ha and the percentage increment of pod yield due to the seed inoculation

over non inoculation was 7.07 and 7.43 respectively in Jayanti and B-4 (Table 1, 2 and 3). Becking (1991) pointed out that on application of molybdenum in groundnut, nitrogen uptake was increased and Mo accumulated at the site of N₂ fixation. Mo is the component of nitrogenase enzyme that fixes the N₂ in legumes (Bond, 1970). Rajbhandari (1991) pointed out that significant positive correlation of pod yield was observed with number of pods per plant, number of pegs per plant and test weight.

Days to flowering: Differences on days to flowering were significant for the genotypes during 2005 and 2006. However, the distinction was not observed due to the seed inoculation techniques of flowering duration. Longer duration for flowering was taken by the genotype B-4 (average of 40 days) than Jayanti (average of 35 days) in both the years (Table 1 and 2).

Days to maturity: Distinction on days to maturity was obvious between the genotypes; however the effect of seed inoculation was not evident in both the years. The difference on days to maturity between Jayanti and B-4 was about 15 days (Table 1 and 2).

Table 1 Effect of genotypes and inoculation techniques on the performance of groundnut, 2005

Treatment	No. of plants /m ²	Flowering days	Maturity days	No. of pods / plant	No of seeds/ pod	Shelling %	Test wt (g)	Pod yield (kg/ha)
V1T1	30.2	35.2	125.2	20.1	3.7	71.1	43.8	2398.64
V1T2	29.3	35.4	125.6	19.2	3.6	70.6	43.4	2076.32
V2T1	29.9	40.4	141.2	15.9	3.1	73.1	45.1	1781.76
V2T2	28.9	40.5	141.5	15.0	3.1	72.6	44.7	1533.92
Mean	29.57	37.8	37.87	17.56	3.37	71.85	44.2	1947.66
CV%	5.2	3.46	4.52	5.34	9.33	1.04	1.36	11.41
LSD (0.05)	NS	0.508	0.529	0.86	0.29	0.68	0.55	219.30

Nodulation: Differences among the genotypes were not distinct in producing the number of nodules per plant whereas the differences were distinct due to the seed inoculation by rhizobium and molybdenum in both the years for this trait. The result suggests that the nodulation in groundnut can be enhanced due to rhizobium inoculation. The positive correlation was observed for rhizobium inoculation and population of root nodules (Table 2).

Soil fertility status: The fertility status of soil was assessed by taking the soil samples before sowing and after harvest of the crop. Bench mark soil analysis of the experimental plots was carried out before the trial establishment during the first year and the final status of soil nutrients were assessed after the second year's crop harvest. The laboratory

analysis report revealed that the improvement on major soil nutrients, organic matter and pH was observed after the second year's crop harvest. It might be due to the effect of molybdenum activity in the soil.

Table 2 Effect of genotypes and inoculation techniques on the performance of groundnut, 2006

Treatment	No. of plants /m ²	Flowering days	Maturity days	No. of pods/plant	No of seeds/pod	Shelling %	No. of nodules/plant	Test weight (gm)	Pod yield (kg/ha)
V1T1	30.5	35.2	126.7	20.5	3.40	71.3	117.34	44.0	2488.64
V1T2	30.5	35.0	126.6	19.3	3.30	70.8	74.35	43.3	2181.96
V2T1	30.6	40.7	141.4	16.6	3.00	72.8	114.25	44.5	1806.08
V2T2	30.0	40.6	141.3	15.1	2.90	72.6	74.46	43.8	1506.72
Mean	30.4	37.9	134.0	17.87	3.15	71.87	95.1	43.9	1995.85
CV%	2.17	2.52	2.02	6.45	11.1	0.97	12.83	1.99	15.53
LSD (0.05)	NS	0.529	2.485	1.07	0.321	0.64	11.2	0.801	287.83

Higher yields of groundnut in the experimental plots might be due to the available pH status in the soil. Studies have shown that the higher grain yields of groundnut are attained on slightly acidic soils with pH 6.0-6.5. The findings of the experiments are in accordance with the findings of Woodroof (1987).

Table 3 Effect of genotypes and inoculation techniques on the performance of groundnut combined over years (2005-06)

Treatment	No. of plants /m ²	No. of pods / plant	No of seeds/ pod	Shelling %	Test weight (g)	Pod yield (kg/ha)
V1T1	30.3	20.3	3.5	71.2	43.9	2543.64
V1T2	29.9	19.8	3.4	70.7	43.1	2375.64
V2T1	30.2	15.8	3.1	72.95	44.8	1713.92
V2T2	29.4	15.2	3.0	72.60	44.1	1595.32
Mean	29.9	17.77	3.26	71.86	43.9	2057.13
CV%	4.71	5.97	11.64	1.39	2.07	14.74
SED for year (Y)	NS	0.335	0.121	0.315	NS	NS
SED for treatment (T)	NS	0.237	0.085	0.223	0.96	95.84
SED for Y X T	NS	4.474	0.169	0.445	NS	135.54

Increment of organic matter percentage was least (0.15) in the soils with no seed inoculated and the highest was 0.38 in Jayanti followed by B-4 (0.20) with seed inoculated. Increment on the status of soil nitrogen was meager ranging from 0.01 % in

B4 without seed inoculation to 0.05 % in Jayanti with seed inoculation and hence, was found to be influenced by the seed inoculation. The studies on the contribution of biologically fixed N to the total nitrogen requirement of groundnut plants have shown that root nodules can fix atmospheric nitrogen to an extent of 200-260 Kg/ha (Williams et al., 1998). In case of available phosphorus content in soil, the variation was 10 ppm in B-4 without seed inoculation to 22 ppm in Jayanti with seed inoculation. Since it is an essential component of DNA, and plays role in metabolism of leguminous plants. Since P is one of the slow releasing nutrients and its uptake efficiency is also slow (Reid & Cox, 1986). Similar was the case with available potassium, where the increment variation was less under non inoculated condition than the seed inoculated condition (Table 4).

Table 4 Effect of rhizobium inoculation on soil fertility status of groundnut during 2006

Treatment	pH		Organic Matter (%)			Total N (%)			Available P (ppm)			Available K (ppm)		
	BM	AH	BM	AH	Ch	BM	AH	Ch	BM	AH	Ch	BM	AH	Ch
Jayanti treated	5.6	5.7	1.62	2.00	0.38	0.22	0.27	0.05	47	69	22	210	216	06
Jayanti untreated	5.6	5.7	2.10	2.25	0.15	0.15	0.16	0.01	57	69	12	210	223	13
B-4 treated	5.7	5.9	2.01	2.21	0.20	0.16	0.18	0.02	55	68	13	210	234	24
B-4 untreated	5.7	5.8	2.54	2.59	0.15	0.16	0.17	0.01	58	68	10	210	233	23

Note: BM=Bench Mark, AH= After Harvest , Ch= Change

Table 5 Performance of promising genotypes of groundnut with or without seed inoculation by rhizobium under front line demonstration, 2006

Genotypes	Pod yield (Kg/500m ²)		Yield increment (kg/500m ²)
	inoculated	non inoculated	
Jayanti	98.0	68.5	29.5
B-4	85.7	79.76	5.94

Table 6 Partial Budgeting for Jayanti of groundnut with or without seed inoculation

Particulars	Jayanti		B-4	
	Ino	Non-ino	Ino	Non-ino
Average pod yield (Kg/Rop)	98	68.5	85.7	76.53
Gross field Benefit (Rs/Rop)	5390.00	3767.5	4713.50	4331.80
Cost of seed inoculation Rhizobium (Rs/Rop)	459.75	0.00	459.75	0.00
Total cost that Vary (Rs/Rop)	459.75	0.00	459.75	0.00
Net Benefit (Rs/Rop)	4440.00	3767.5	4253.75	4209.15

Note: Price (Rs): of Groundnut: 55/kg; Molybdenum: 29400/kg; Rhizobium: 24/20 g. pkt

Economic analysis: Yield increment due to seed inoculated crop over non-inoculated was 29.5 kg in Jayanti and 5.94 kg/ropani in B-4 (Table 5). Partial budgeting of both the

genotypes with or without seed inoculation revealed that the net benefit was the highest of NRs. 4440.00/500 m² in Jayanti with seed inoculated by rhizobium and molybdenum followed by the same treatment of B-4 having NRs.4253.75/500m² of land (Table 6).

CONCLUSION

The genotypic performance of Jayanti over B-4 in the hills was better for yield and related attributes. Contribution of the rhizobium and molybdenum seed inoculation on yield and related attributes of the groundnut was apparent. Jayanti having thin shelled, small but perfect fertile pods, early in flowering and maturity as compared to B-4 was preferred by the farmers. Net benefit from Jayanti with seed inoculation by rhizobium and molybdenum was also higher than B-4. Similarly, the contribution of seed inoculation on root nodulation was also found significant. Influence of seed inoculation was also distinct on soil fertility improvement. The findings of the study suggest relative importance of seed inoculation of groundnut by rhizobium and molybdenum on yield formation and soil fertility management.

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Livelihood Strategies of Farm Families: Micro-level Focus using Generalized Algebraic Modeling System (GAMS)

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ABSTRACT

Linear optimization through Generalized Algebraic Modeling System (GAMS) explains the structure of mathematical decision model followed by an assessment of the validity of base model. Finally, it analyses future development with and without implementation of different strategies. This paper aims at optimizing smallholder farmers resources use in the rural subsistence and peri-urban semi-commercial farming areas of Nepal. Household data were collected using structured questionnaire administered through schedule. Socio-economic and farm-family resources were analyzed using farming system approach while willingness to pay (WTP) for organic vegetables were analyzed through WTP approach. Strategies such as integrated soil management, intercropping, improved livestock feeding and price premium to organic vegetables were tested and the impact investigated. Integrated fertility management shows an appreciable increase in farm income (48%) in the subsistence farming areas. With the policy set to provide higher premiums (40% and 60% WTP for organic vegetables over inorganic counterparts) to the organic producers, the smallholder organic growers would improve farm income (4% and 7% respectively). However, a sensitivity analysis shows that reducing selling prices of organic vegetables by 10% than what they are presently paid would discourage farmers from implementing their production. This reveals that government should frame a policy to support organic producers and promote integrated practices of land management in the hilly areas.

Key words: Base model, GAMS, Linear programming, Organic vegetables, Strategy testing

INTRODUCTION

During the last decade or so, the agriculture and environment in the smallholder urban and peri-urban fringes of Nepal experienced a negative change principally due to the indiscriminate use of agro-chemicals, declining farm size and degradation of the resource base (Bhatta & Doppler, 2011; Bhatta & Neupane, 2010; Bhatta & Doppler, 2010). While peri-urban semi-commercial farming requires some prudent farming practices such as

organic methodologies, rural marginal hills desperately demands amendments in available production practices within the set of available resources (Bhatta, 2010b). Efficient decision-making and optimal allocation of resources in the farm, family and household is crucial because of the scarcity of resources.

Resource optimization through Generalized Algebraic Modeling System (GAMS) explains the structure of the mathematical decision model followed by an assessment of the validity of base model (Bhatta, 2010a). Finally, it analyses future development with and without implementation of different strategies. The process of modelling farming decisions, where farm and household has complex interrelations with limited resources, entails an understanding of the interrelations and reflects them in a model. The development of the rational answer to the decision-making problems requires precise information (Sharifi & van Keulen, 1994). Different actions in the farm and family sectors lead to different levels of realization of family objectives (Kaburanyaga, 2007). The families are, therefore, faced with a decision-making problem between alternative levels of the objective realization (Wallace & Moss, 2002). The modeling of family decisions aims at determining the optimal family resources allocation by finding what is feasible with a given limited resources (Blair, 2007). Linear programming (LP) is frequently used to provide a guide to the farmers for efficient resources use and subsequently simulate future development by testing different strategies.

LP is a mathematical method of determining profit maximization by combining farm enterprises that is feasible with respect to a set of farm constraints (Hazell & Norton, 1986). In mathematical parlance, LP is the process of finding an optimum outcome from a set of the constrained resources, where the objective function and the constraints can be expressed in the linear forms. Though this linearity requirement may seem very restrictive, a great many real-world problems can be modeled using LP. This is true for the agricultural sector as well; indeed problems arising in agriculture frequently demonstrate this linearity (Demir, 2005). The LP model is a method that can represent the whole farm planning.

This articles aims at finding the optimal mode of resource use in different farming zones. Improvement of the living standard as a major objective is expressed in the model by maximization of the farm-family income and optimization of the resources allocation.

METHODOLOGY

The study area and farming zones

The research was conducted in the rural and peri-urban areas of Bhaktapur and Lalitpur districts of Nepal. While peri-urban farms are semi-commercial, rural farms are more or less subsistence-oriented. Accordingly, farm-family problems with respect to agriculture production are different in different areas. As rural hill farmers don't have ample market

orientation, these family farms were grouped as subsistence farm (zone) while two groups of farms were formed in peri-urban areas. Smallholder farmers with organic production (mostly vegetables produced organically) were grouped as smallholder organic farms (zone) and inorganic farms were grouped as commercial inorganic farms (zone).

Sampling and the data

Simple random sampling design was employed in selecting 35 farm families from smallholder organic zone while 95 households were selected through spatial sampling design. Structured questionnaire was used for collecting information related to socio-demographic attributes, resources availability and use and farm-families objectives. Finally these data were analyzed descriptively following farming system approach. The mean values of required data were incorporated in modeling. The interpretation of the modelling results is a static comparative one considering a 'with' and 'without' concept. The difference between future development with improvement strategies in resource use and management and without the strategies is called the impact of the future development.

Empirical model

The design of the LP model includes an objective function and the constraints subject to which the objective function is optimised. This is expressed in a series of relationships and equations. The model was validated by simulating the past and by comparing model results with the reality. The base model, once adequately represented the reality, was used in testing strategies. Finally, the response of the model towards several situations was assessed and conclusions drawn accordingly. Figure 1 presents the GAMS modelling process of farm-household systems.

GAMS is a software package to solve the systems of equation. It contains a large menu of solvers for different purposes. Various kinds of economic models can be written down as a system of equations, including systems analysis, non-linear optimization and equilibrium modeling. A crucial algebraic modeling element is the identification of indices (also referred to mathematically as a subscript, or in GAMS as a SET) in the GAMS. The compactness with which one can specify a model depends on the characterization of items with indices. However, the readability of the model depends on the indices being disaggregate enough to reveal essential features.

Among different solvers available in the GAMS, *ILOG CPLEX* is a default one. It is a tool for solving linear optimization problems, commonly referred to as LP problems. The optimal solution that *ILOG CPLEX* computes and returns is: Variables $x_1, x_2, \dots, x_n$. The first step in GAMS modeling is to write an input file.

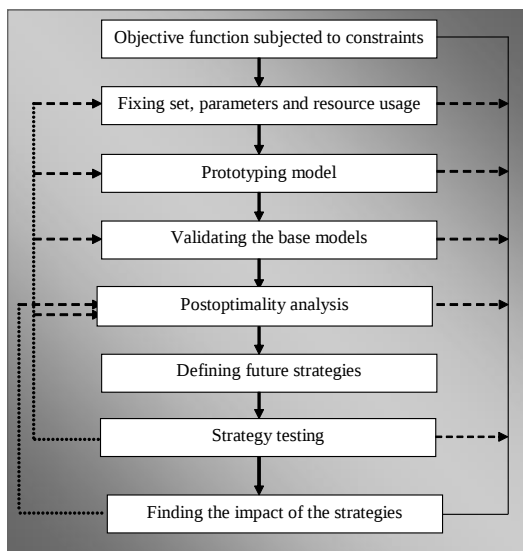


Figure 1 The process of modelling farm family decisions in the GAMS environment
(Adapted from Bhatta, 2010a)

The general structure of a simple GAMS input file contains the following elements:

Set

{different activities in the model represented by the set}

Parameters

{gives the data or exogenous constants of the model; these values are fixed}

Variables

{indicates the variables that will be determined within the model}

Equations

{first the equations have to be declared and then they are defined}

Model

{the model is the given name}

Solve

{the solution mode is specified, as well as a declaration whether the optimand should be maximized or minimized}

The above elements are empirically presented hereunder:

Set (j) different activities in the model

/crop production, livestock production, household consumption, selling of the surpluses, food, feed and fertilizer buy, supply and requirements of N, labour hiring, farm expenses, off-farm activities/;

Set (i) resource constraints

/different types of the land in different seasons, family labour in the farm and off-farm, hired labour, crop yield, dry matter, nutrient supply, family expenses, cash balance, credit/;

Parameter

Cost (j) cost or expenditure of the farm activities

/cost of production of crops and livestock, cost of food, feed and fertilizers, wage for hired labour/;

Price (j) price or revenue of the farm products and off-farm activities

/selling price of crops and livestock, per day income of family labour from salary and wage/;

Con (i) resource endowment/constraints

/different land types in different seasons, family labour in the farm and wage, family labour in the salary, hiring of the labour/;

RU (i,j) matrix of resource usages (As depicted in Table 1)

Table 1 Matrix of resource usage ($RU_{i,j}$)

Activities Constraints	Rainy season ^s	Winter season ^s	Spring season ^s	Livestock production	Household consumption	Crop sale	Livestock sale	Food buy	Feed buy	N-fertilizer buy	Manure buy	Family expenses	Hired labour	Off-farm income	Credit
Lowland															
Rainy	1														
Winter		1													
Upland															
Rainy	1														
Winter		1													
Spring			1												
Grassland				1											
Labour	a_{ij}	a_{ij}	a_{ij}	a_{ij}									-1	1	
Off-farm labour														1	
Crop production	$-a_{ij}$	$-a_{ij}$	$-a_{ij}$		1	1		-1							
Dry matter	$-a_{ij}$	$-a_{ij}$	$-a_{ij}$	a_{ij}				-1							
Livestock production				$-a_{ij}$			1								
Fertilizer-N [†]	a_{ij}	a_{ij}	a_{ij}							-1					
Manure	a_{ij}	a_{ij}	a_{ij}	$-a_{ij}$							-1				
Family expenses												1			
Cash balance	a_{ij}	a_{ij}	a_{ij}	a_{ij}		$-a_{ij}$	$-a_{ij}$	a_{ij}	a_{ij}	a_{ij}		a_{ij}	a_{ij}	$-a_{ij}$	$-a_{ij}$
Credit															a_{ij}

Note: ^sseasonal crop production activity, [†] a_{ij} takes negative value for the legume crops

Equations

$$\text{Obj} \dots \sum (j, \text{price}(j) * x(j) - \text{cost}(j) * x(j)) = E = Z; \quad (1)$$

$$\text{Constraint}(i) \dots \sum (j, RU(i,j) * x(j)) = L = C(i); \quad (2)$$

Equations (1) and (2) can mathematically be expressed as:

$$\begin{aligned} \text{Maximizing} \quad & Z = \sum_{j=1}^n P_j X_j - C_j X_j \quad (3) \\ \text{s. t.} \quad & \sum_j A_{ij} X_j \leq C_i; \quad \text{where } X_j \geq 0 \end{aligned}$$

Where:

- Z the objective function of maximizing total family income, which equals $c_1x_1 + c_2x_2 + \dots + c_nx_n$; where c_j is the contribution (or objective function coefficient) of each unit of X_j to the objective function
- X the level of activity j of the farm-household, the decision variables where $j = 1, 2, \dots, n$; that represent the levels of the activities undertaken
- C the costs of the j 's activities
- P the price of output j 's activities per unit
- n the possible number of activities
- A_{ij} the required i^{th} resource in producing one unit of j (input-output technical coefficients)
- C_i the amount of available resource i , the i^{th} linear constraint can be expressed as $a_{i1}x_1 + a_{i2}x_2 + \dots + a_{in}x_n \leq C_i$ ($i=1, 2, 3, \dots, m$), where C_i denotes the upper limit imposed by the constraint and a_{ij} denotes the usage of the items in the i^{th} constraint by one unit of x_j .

The objective function of the model is to maximize the farm and family income in each farming zone subjected to a set of constraints that have been formulated in the form of equations or inequalities. Maximization of the farm income comes mainly through maximizing the values of crop and livestock sales and minimizing the costs of production. Home consumption has no value in the objective function of the model. Therefore, the value of subsistence and household will be added externally to the farm income. The same is applied for the fixed costs of the farm, which are not included in the models but will be deducted externally from the value of the objective function.

Prototyping empirical model

After formulating the basic structure of the model, it was run to simulate the real situation of the farming families. Hazell and Norton (1986) illustrate the need to calibrate the model when for instance, the model results show an overproduction of a crop that may be caused by (1) overestimates of yields, (2) underestimates of input requirements, (3) underestimates of input prices, (4) yield and input errors for competing crops, and (5) misspecification of the market forms or farmer decision rules.

In the first step, the model was run to see the maximization of the family income using a given set of constraints. However, the result was substantially different than reality. Therefore, model prototyping was needed to approximate the model results with the reality. The free selection approach of prototyping did not select many of the farm activities which are actually being adopted by the farmers. This is basically because of the higher cost or lower price or the combination of both. To make it as representative as possible, two approaches were followed. The first approach was to obligate the model to select some activities that are extremely mandatory for the farmers, for example livestock production as it has religious and farming significance, particularly in the remote hills. Similarly, certain household consumption such as rice, wheat and vegetables were affixed. This somehow reflected the reality. At the same time, some more constraints were considered such as manure requirements and supplies and fertilizer requirements of the crops. Both of these approaches reflected farm reality to a greater extent.

Model validation

The validation process begins with a series of comparisons of model results with the reported actual values, the variables. Wide deviations of the model results from reality may indicate that the initial assumptions were wrong and therefore, would require modifications. It can be alternatively concluded as well that the assumptions were not all wrong but the farmers are operating in an inefficient way and it is their management practices that need to be changed (Blair, 2007). This is what Hazell & Norton (1986) suggested by stating that while judgments on the model's adequacy must be made, it is also important to continue to improve the model. The process of improving the model is called calibration of the model or sensitivity analysis. Validation of the three basic models was done through the comparison of farm, off-farm and family income and resource uses for different combinations.

The base models that apply to subsistence and smallholder organic farming predicted higher farm and family income and lower off-farm income (Figure 2a, c). The differences between the survey and model results indicate the models achieve a good fit to the survey information. The commercial inorganic farming model predicted higher farm, off-farm and family income compared to base situation (Figure 2b). But, nevertheless, it shows a good fit.

Post-optimality analysis of the basic models

Most LP-based studies include a post-optimality investigation of how a change in the data changes the solution (Hazell & Norton, 1986; Hagle & Wallace, 2003). Sensitivity analysis, which is generally recognized as an important part of LP (Ward & Wendell, 1990), is a systematic study of how sensitive solutions are to a small change in the data. Post-optimality analysis was done by considering the variable not in the solution by increasing the selling price and decreasing the cost associated with it. The test was done

step by step considering cost in the first step, selling price in the second and both in the third step. GAMS Loop was constructed considering some upper and lower bounds of the particular variable not in the solution and its sensitivity were tested accordingly. The results of the post-optimality tests showed that these models passed this step and are completely fine for strategy testing. However, price sensitivity of organic vegetables was found substantial. A slight decrease in price of organic vegetables (10% less than what it is in current situation) would lead to non appearance of such activity in the model.

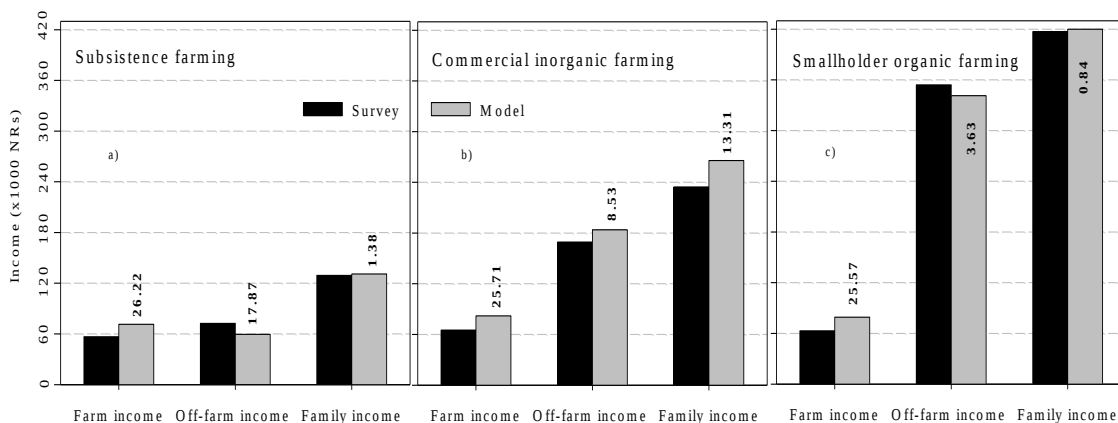


Figure 2 Comparison of farm, off-farm and family income between the survey and model results for three farming zones

Note: Figures on the bars indicate the percentage difference in income due to the model over surveyed data

RESULTS AND DISCUSSION

Future strategies and scenarios to be tested

The simulation of strategies in a farming system seeks at predicting how the system at a farm/household might react in the future under assumed strategies or changes in the policy framework. All of the strategies tested are elaborated below.

Strategy 1: Integrated fertility management

The problem of fertility decline is noted in all study zones and the reason and the degree of decline are different in different areas. The subsistence zone, for instance, lies in the rural area with moderate to high degree of slope lands. Sloppy land, coupled with the cultivation of marginal hills, definitely leads to higher soil erosion, top soil washing and

hence less return each year. The commercial inorganic farming zone, that lies on the lowland relatively flat bottom, faces the problem of fertility decline which is basically a function of the unbalanced use of agro-chemicals particularly urea-N (Bhatta, 2010a,b). Intensive cultivation of crops depletes soil nutrients if organic and inorganic fertilizer additions are insufficient (Brown & Shrestha, 2000). Nutrient budget modelling indicates that the soil nutrient pool is being depleted under both intensive irrigated and extensive rainfed production systems (Brown et al., 1999), which suffers from insufficient nutrient inputs particularly maize dominated rotation systems (Schreier et al., 2001). Enhancing farm income through higher crop production is crucial in the study area as a sizable portion of farm income comes from crop production. The smallholder organic zone is somehow managed satisfactorily. But nevertheless, the lowland in this zone faces a similar fate as of the commercial inorganic zone.

The integrated fertility management strategy aims at achieving better fertility through contour farming and terracing, improving composting practice and field incorporation, and application of chemical fertilizer in the modest amount, wherever necessary. It is assumed that farmers would adopt proper composting practice and apply ample amounts of farm manure on the field and incorporate it immediately after field application. It is also assumed that organic manures are available at the time of need. Similarly, in the remote flat land, farmers are supposed to use the modest amount of chemical fertilizer and ample amounts of farm manure to achieve better yield and keep to fertility higher. Integrated fertility management in the accessible areas imply the use of the modest amounts of agro-chemicals and sufficient use of farm manure along with legumes in the rotation, mulching and improving quality of farm manure.

Strategy 2: Promoting intercropping in the farms

Despite the suitability of certain grain legumes as intercrops mainly in the upland farming and in the bund of lowland fields, the usual farmer's practice is not to give credence to intercropping. Farmers in the upland area mainly cultivate maize which is exhaustive in nature. Legumes can be well accommodated in the upland and with many vegetables.

Strategy 3: Improved livestock feeding and management

This strategy is applied only in the subsistence farming zone. In the rural areas, dairy enterprise is key a source of farm income. Despite this implication, milk yield from cows and buffalo is not satisfactory. The improved breeds of livestock would need adequate care and management including nutritious feed to excel their potentiality. Therefore, in order to get higher milk yields from these species, improved feeding strategy was considered. The assumption is that some more nutritious fodders such as legumes and concentrated feeds and sweeteners help livestock express their genetic potential that is reflected in the milk production. It is also assumed that such feed ingredients are easily available in the market and are within the purview of the farmers. Similarly, cooperative

milk selling is fully functional in the future too and supply the higher amount of milk in the market would not have any problem.

Strategy 4: Higher price of the organic vegetables

This strategy is applied only in the organic zone as many of the farmers in this zone produce organic vegetables targeted at the niche market. Despite a good deal of demand for such vegetables in the limited market, the price farmers get is not reasonable. Organic producers deserve some payment for environmental services (PES) and this should basically come from government support and consumers willingness to pay more for organic products (Bhatta & Doppler, 2011). The trade-off analysis reveals that consumers would be willing to pay more to organic vegetables over the inorganic ones (Bhatta, 2010a). At present, the premium farmers are getting is almost 20% (data not shown). While many organic growers show ecological motivations, they deserve price premiums for their products. Therefore, this strategy considers 40% and 60% price premiums to organic vegetables as compared to inorganic ones. Certain provisions such as certification, cooperative farming and marketing and establishment of well-equipped markets for organic products would provide substantial role in achieving higher premium for organic products. Government supports along with non-governmental bodies and consumers' willingness to ecological products are very important for this.

Impact of different strategies on farm-family income and resource use in the subsistence farming zone

Impact on farm-family income due to different strategies of development is presented in Figure 3a. The intercropping strategy increases farm income by 4.41% while improved feeding and integrated fertility management increase farm income by 34.73% and 48.18% respectively. Family income is also increased with each strategy. The highest increase in family income (17.79%) has been noticed with the strategy of improved livestock feeding.

All tested strategies utilize the available land and labour. With intercropping only 0.51 ha of land is utilized in the winter upland (Table 2). With intercropping, 50% of the less area under maize has been cultivated. It is because of the fact that intercropping seems to be more remunerative than sole cropping, and hence 0.3 ha of the upland is going to intercropping. The basic model shows 0.1 ha under legume production; however, fertility management strategy shows that 90% of the area is cultivated with sole legume species. It is because although the cost of production is lower than other crops, the yield is also lower. *Ipso facto*, their indirect contribution in N addition leads to the appearance of legumes in the solution. But once intercropping strategy is introduced, area under sole cultivation of legume is zero; and significant portion of the land is going for intercropping. A large increment in the cole crop area is obtained with fertility

management (1080) and intercropping (60). Vegetable cultivation is declined to 90% with fertility management strategy and with intercropping.

Only one cow is in the solution with each strategy while 2 buffaloes are coming in the strategy of integrated fertility management. This is because integrated fertility management considers the importance of farm manure being supplied through livestock species. With intercropping there is 50% reduction in the buffalo numbers. This is because soil fertility, at the larger extent, is managed by those legumes which, to some extent, replace the organic manure need from livestock.

Table 2 Resource use at the subsistence farming zone under different strategies compared with without strategy

Resource use	Without strategy	With strategy of		
		Fertility management	Intercropping	All integrated
Lowland rainy	0.2	0.2	0.2	0.2
Lowland winter	0.2	0.2	0.2	0.2
Upland rainy	0.6	0.6	0.6	0.6
Upland winter	0.6	0.6	0.51 (-15)	0.6
Upland spring	0.3	0.3	0.1 (-67)	0.3
Grassland	0.25	0.23 (-8.00)	0.23 (-8)	0.25
Catch crop	0	0	0	0.2
Rice	0.2	0.2	0.2	0.2
Wheat	0.2	0.2	0.2	0.2
Maize	0.6	0.59 (-1.67)	0.3 (-50)	0.2
Legumes	0.1	0.01 (-90)	0	0.3 (200)
Intercropping	0	0	0.3	0.3
Cole crop	0.05	0.59 (1080)	0.1 (100)	0.48 (860)
Vegetables	0.1	0.1	0.01 (-90)	0.1
Cows	1	1	1	1
Buffaloes	2	2	1 (-50)	1 (-50)
Goats	5	5	5	6 (20)
Poultry	7.77	0	0	0
Total family labour	1300	1300	1300	1300
Wage earners	605	268 (-55.70)	622 (2.81)	397 (-34.38)

Note: Figures in the parentheses indicate the % differences with and without strategies

Impact of different strategies on farm-family income and resource use in the commercial inorganic farming zone

There has been a progressive increment in farm income with the integrated fertility management and intercropping strategies (Figure 3b). The impact of different strategies on farm income is not substantial as that in the subsistence farming zone because of less

land and off-farm opportunities available nearby. The static model in this farming zone does not simulate encouraging result. It is because most of the lands are fertile naturally. Currently, farmers are noticing the declination in fertility. However, fertility declination is a gradual process and a substantial impact on yield could be noticed some 5 or 10 years later. Therefore, integrated fertility management practices are currently needed so that there is no further degradation of the resources.

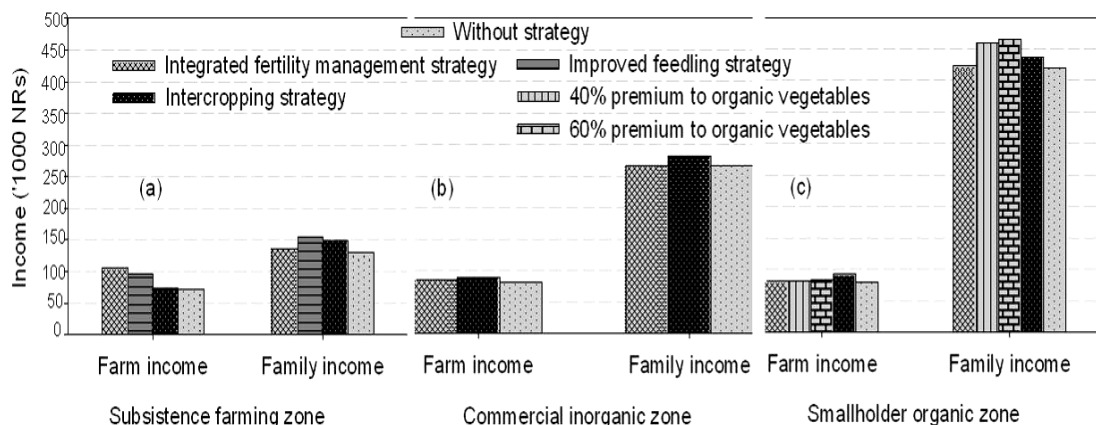


Figure 3 Farm-family incomes (NRs) with and without strategy tested at (a) subsistence farming zone, (b) commercial inorganic zone, and (c) smallholder organic farming zone

In terms of the resource use associated to the tested strategies, all lands and labour are fully utilized (Table 3). Integrated fertility management reduces maize and cole crop areas by 10%. The vegetable area is reduced by 50% with this strategy. Number of cows is the same in each strategy while that of buffalo is not realized in the solution. Goat and poultry production are minor activities in this zone and therefore do not appear in the solution.

Impact of different strategies on farm-family income and resource use in the smallholder organic farming zone

All the strategies show gradual improvement in the farm income (Figure 3c). Higher increment is realized with intercropping (14.84% over no strategy). Family income is also increased with all strategies and it is higher with the 60% premium set for organic vegetables.

All of the land and labour resources are adequately utilized by the tested strategies. The maize area is declined with all strategies (Table 4). This is because a sizeable portion of the maize area goes to intercropping, as maize is the most important main crop component in intercropping with legumes. The cole crop area declines with integrated soil fertility management and it is not in the solution with intercropping strategy. Most of the vegetable area is occupied with each of the strategy. With integrated soil fertility management, 20% vegetable area is reduced.

Table 3 Resource use at commercial inorganic farming zone under different strategies compared with without strategy

Resource use	Without strategy	With strategies of	
		Fertility management	Intercropping
Lowland rainy	0.1	0.1	0.1
Lowland winter	0.1	0.1	0.1
Upland rainy	0.1	0.1	0.1
Upland winter	0.1	0.1	0.1
Grassland	0.2	0.2	0.2
Catch crop	0	0	0
Rice	0.1	0.1	0.1
Wheat	0	0	0
Maize	0.1	0.09 (-10)	0
Legumes	0	0	0
Intercropping	0	0	0.1
Cole crop	0.1	0.09 (-10)	0.1
Vegetables	0.03	0.02 (-33)	0
Cows	2	2	2
Buffaloes	0	0	0
Total family labour	1200	1200	1200
Wage earners	644	645 (0.15)	641 (-0.47)

Note: Figures in the parentheses indicate the % differences between the survey and model

Table 4 Resource use at smallholder organic farming zone under different strategies compared to without strategy

Resource use	Without strategy	With strategies of	
		Fertility management	Intercropping
Lowland rainy	0.25	0.25	0.25
Lowland winter	0.25	0.25	0.25
Upland rainy	0.1	0.1	0.1
Upland winter	0.05	0.05	0.05
Grassland	0.05	0.05	0.05
Catch crop	0	0	0
Rice	0.25	0.25	0.25
Wheat	0.2	0.15 (-25)	0.2
Maize	0.1	0.08 (-20)	0.04 (-60)
Intercropping	0	0	0.05

Cole crop	0.05	0.03 (-40)	0.05
Vegetables	0.05	0.04 (-20)	0.05
Cows	1	1	1
Buffaloes	0	0	0
Poultry	100	100	100
Total family labour	1100	1100	1100
Wage earners	534	537 (0.56)	540 (1.12)

Note: Figures in the parentheses indicate the % differences between with and without strategies

CONCLUSION

All of the tested strategies demonstrate an increment in farm-family income and the impact is higher in the subsistence farming zone. Integrated fertility management shows appreciable increase in farm income (48%) in the subsistence farming while the increment due to this strategy is almost 3.5 percent each in the commercial inorganic and smallholder organic zones. Promoting intercropping increases farm income by almost 4.5, 9 and 17 percent, respectively in the subsistence, commercial inorganic and smallholder organic zones. Similarly, organic growers would have their farm income increased once higher premiums are paid to their products. Some provision of premium either in the form of input subsidy or other forms of government supports should be needed for those farmers who are paying attention to the sustainable use of the available resources. While a slight decline in the price of organic vegetables would distract growers to follow organic methodologies, there has been immense scope of expansion of organic production in peri-urban areas.

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Agronomic Evaluation of Cattle Manures for Cabbage Production: Animal Gender and Physiological Conditions

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ABSTRACT

Soil fertility management and the associated rationalised recommendations is a big threat to crop production in sub Saharan Africa. Particularly in Uganda, vegetable production is among the lucrative crops grown mainly by small-scale farmers for local consumption and urban markets. The strategic entry-point lies in considerations of materials that are locally available within the farmers' jurisdiction such as cattle manure, both solid and liquid, which are largely accessible on-farm cost-free. Whereas efforts have been made by farmers to compost the solid forms of cattle manure, issues related to urine utilisation are still scantily understood. Cattle manure, particularly urine, is under-utilised as a fertiliser and an agronomic potential. The experimental crop used was cabbage, Brassicae oleraceae var capitata L.; and specifically, the Prize Drumhead variety. Promoting the use of cattle urine is important; and this study was therefore designed to address the following objectives: (i) determine the optimum rates for cabbage production in central Uganda and (ii) evaluate the effect of animal gender on urine nutrient quality. This study was conducted at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK), during 2004- 2005. The study involved the treatments of solid (S) and liquid (L) manure, which, were interactively applied at 0, 50+50 (L+S), 100 (S), 100+100 (L+S), 100 (L), 200 (S), 200 (L) and 200+200 (L+S) kg N ha⁻¹ in a factorial based randomised complete block design (RCBD), in a split-split arrangement. Liquid manure was applied 2 - weekly in doses of 50, 30 and 20% till initial stages of cabbage head formation. Plot size was 4 m x 3 m. An alley of 1.5 m was maintained to separate blocks. Furthermore, 1m paths separated plots within blocks. Irrespective of gender and physiology stage of animals' application of urine and solid manure and their combinations, cabbage yield parameters increased significantly ($p < 0.05$). Urine at a rate of 200 (L) kg N ha⁻¹ was superior to faecal manure in terms of cabbage yield parameters. However, cabbage yield was highest when urine and faecal material were applied jointly at a rate of 200+200 (L+S) kg N ha⁻¹. The rate of application resulted into 25% greater than the sole application of the two manure forms at the 400 kg N ha⁻¹ rate. In particular, bull urine at 200 (L) kg N ha⁻¹ achieved the highest cabbage yields, while heifer manure with the combination of 200+200 (L+S) kg N ha⁻¹ was superior to the rest of animal gender and physiological. Female animals, on the other hand, generally had superior cabbage parameter yields to the male (bull) gender, under the interactive solid and urine manure.

Key words: Soil fertility, Urine, Shoot and head yields.

INTRODUCTION

Small- scale farming is predominant in sub-Saharan Africa and comprises of crop and livestock production systems. In particular, cattle excrete plenty of urine and faecal materials, which are largely disposed off as wastes on farm. Unlike solid cattle manure (dung), urine is rarely applied though it is equally a potential fertiliser especially for cash improvised small-scale farmers. Declining crop yields attributed to nutrient depletion will require use of all available manure sources particularly animal refuse (solid or liquid) among low external input farming systems. Animal urine, rich in readily available plant nutrients (Vinneras, 2002; Vinneras & Josson, 2003; Kleinman et al., 2005), is a feasible alternative since majority of farmers in the region practice mixed farming, with cattle constituting the largest proportion of the livestock sector (Kajura, 2001). Cattle manure, particularly, urine is inadequately utilised due to absence of science-based supportive information. Studies are, thus necessary to explore how these valuable resources that can be utilised for soil fertility management, particularly in the horticultural industry, which is increasingly lucrative in the country (NSW, 2006).

Cabbage (*Brassica oleracea* var *capitata* L.) is among the most important vegetable crops cultivated in sub-Saharan Africa (SSA) (Karungi et al., 2006). By 2004, the overall SSA annual production was thirty thousand metric tonnes (UF, 2005), with the bulk grown on small-scale farms. In East Africa, cabbage production is mainly for food and cash income by smallholders, especially in rural and peri-urban areas (Sonko et al., 2005). Moreover, cabbage yield in general, and per unit area in particular, has been declining in the sub-region (Musana & Rubaihayo, 2001; FAO, 2002).

In Uganda, the negative production trend has been attributed to a spectrum of factors, but primarily pests, diseases and soil fertility decline (Kanyanjua et al., 1994). The Diamond bark moth (*Plutella xylostella*) and Black rot (*Xanthomonas campestris*) have been singled out as a catastrophic pest and disease of cabbage, respectively, in the country (UNDP, 1998)

In a more recent greenhouse study conducted in Uganda, Tenywa (2004, unpublished), revealed marked cabbage yield responses to cattle urine application. In the same study, cattle urine fermentation and/or dilution before application to cabbage, as practiced by farmers in Uganda, was found to be scientifically unjustified. All that was necessary was to apply the material about 10 cm away from the plants.

Specifically, the objectives of this study were to (i) Establish the optimum rate and agronomic effectiveness of cattle manures in solid and/or liquid forms, for cabbage production in Uganda; and (ii) Establish the potential of cattle manure from different physiological stages and gender status to supply nutrients.

MATERIALS AND METHODS

Study site

This study was conducted at Makerere University Agricultural Research Institute; Kabanyolo (MUARIK) during the first and second rains of 2004. The Institute receives a mean annual rainfall of 1160 mm of bimodal distribution (March-June and September-December). Temperature ranges from 17 to 28 °C, while relative humidity ranges from 40 to 75% (Kabanyolo Metrological Site records, 2005, unpublished). Land physiography is dominantly undulating, with flat-topped laterite caps on the hills and short steep upper slopes and longer gentle lower slopes. This is followed by short slopes that culminate into inland valley swamps (Majaliwa & Tenywa, 1998).

The soils are moderately acidic, with pH ranging from 5.1 to 5.6. They are largely sandy clay loams derived from Precambrian Schist and quartz, and dominated by Kandiudult soil type (Zake et al., 1994). The soils of MUARIK are occasionally fertilised with N, P and K basal fertilisers, as well as cattle and poultry manures. Nitrogen and P are the most limiting nutrients to viable crop production on the Institute's soils and elsewhere in Uganda (Zake, 1993).

Crops and livestock production are practised at MUARIK farm. Dairy cattle dominate the livestock sector, with Friesian constituting the main breed. MUARIK has approximately, 200 heads of cattle. The herd composition is 50 % lactating, 30% heifers and 10-20 %calves. All these are managed within a semi-intensive system, that is, grazed within fenced paddocks as well as fed on concentrates and mineral supplements. A range of pasture and legume species exist on the farm; these forage components are bound to affect the nutrient content in the cattle manure. As such, manure in the solid and liquid forms, is generated in sizeable quantities and almost entirely utilised for crop production purposes. The modest quantity of manure utilised is haphazardly in mixtures of solid and liquid manure, in unknown proportions. Moreover, manure management, right from deposition to application, is observably inefficient; proper management facilities are lacking.

Experimental procedure

The experiment was conducted in a paddock, which had been continuously cultivated without fertiliser application for more than 4 years. Prior to setting up the experiment, soil samples were taken at 0-20 and 20-30 cm depth for site characterisation. The samples were analysed for pH, organic matter, total N and available P, and exchangeable K^+ , Ca^{2+} , Na^+ and Mg^{2+} , using routine procedures (Okalebo et al., 2002).

Treatments included solid and/or liquid cattle manure applied at 0, 50,100, and 200 kg N ha^{-1} equivalents. Besides the manure rates, cattle physiological condition/stage was also considered. For this purpose, bulls, lactating cattle and heifers also formed treatment

factors as they anticipatedly influence manure quality. Furthermore, in order to establish the optimum mix of solid and liquid manures, a range of respective combinations was included, namely, 0:0, 50:50, 100:100, and 200:200 kg N ha⁻¹, solid: liquid mixtures, respectively.

The treatments and their combinations were laid out in a randomised complete block design (RCBD), in a split-split arrangement. Treatments were replicated three times in blocks, which were each sub divided into eight sub plots. For cases where both liquid and solid manure forms were jointly applied, the solid compost was weighed in the rightful quantity on dry weight basis, and applied to the ground surface around the planted seedling.

The solid manure was composted for 90 days, following the procedure, which is three- pit transfer. The rates were applied on dry weight basis, with moisture content determined at 105°C for 24 hours. Urine was fermented for 14 d and undiluted, following Uganda farmers' routine practice (NEMA, 1999). Undiluted, because, Tenywa (2004), reported lack of effect of urine dilution on performance of cabbage plants. The solid material was incorporated in the soil using a garden trowel. The liquid form was measured using a plastic cylinder/beaker, and poured around the plant. The latter was applied at about 10 cm away from the plant to avoid salt injury. The prescribed quantity of urine was applied in two splits, one at seedling stage and the other at the initiation stage of cabbage head formation. On farm blanket application of P at a rate of 22.5 kg ha⁻¹ as single supper phosphate (SSP) was done before transplanting, to take care of phosphorus, which was known to be deficient in MUARIK soils and in the manures (Zake et al., 1994).

The experimental crop was cabbage, *Brassica oleraceae* var *capitata* L, specifically the Prize Drumhead variety. Seedlings of about 15 cm height were obtained from MUARIK nursery section. They were planted in holes of 10 cm x 5 cm dimension, spaced at 75 cm x 60 cm (Beinempaka et al., 1988). They were watered using tap water, immediately after planting with 500 ml per hill. Watering was regularly done to maintain field capacity moisture conditions in the field during the study.

Plot size was 4 m x 3 m; and an alley of 1.5 m separated blocks. Peripheral paths between plots were 1m wide. Shortly after planting, the plots were mulched up to 15 cm thick with mowed dry grass, fully covering the surface to conserve moisture, control weeds and soil erosion. Furrows of 45 cm deep were dug and maintained between plots in order to prevent runoff overflow and its attendant mix up of treatments. Hand-weeding was done regularly whenever weeds were spotted. Aphids (*Aphis spp*) and Diamond bark moth (DBM) (*Plutella xylostella*) were controlled using Dimethoate insecticide at a rate of 10 ml in 20 L of water (Beinempaka et al., 1988). Diathane M45 at a rate of 10 g mixed with 20 L of water was sprayed to control down mildew, a fungal disease caused by *Eremospora persitice*. Black rot (*Xanthomonas campestris*), a bacterial disease, which affected the base of cabbage heads were rouged out (Musana & Rubaihayo, 2001). The

cabbage heads were harvested continuously as they matured (80-90 d after planting). Six plant samples were taken from each plot. Dry weights of cabbage heads and shoots were determined using plants cut at the soil level with a sharp knife. The plants were separated into heads and stalks prior to each part being cut into small pieces for drying in the oven at 60 °C for 48 h. Similarly, a pair of samples, solid and liquid manures, was taken fresh each from five bulls, heifers and lactating Friesian cattle separately, for laboratory characterisation for pH, and total N and P. As described in the section of this theory, the solid samples were air-dried at room temperature for 7 days and ground in a porcelain mortar and pestle. Solid manure pH was determined in distilled water in a ratio of 1:2.5, using the pH electrode procedure (Okalebo et al., 2002). Additionally, 500 mg from each solid manure sample after oven drying was digested in concentrated sulphuric acid for total N and P analysis. Total N was analysed using the Kjeldahl technique, while total P was tested using colorimetry (Okalebo et al., 2002).

Data collected were subjected to analysis of variance using GenStat software, Second Edition (Rothamsted, 1995). Significant treatment means were separated using Fisher's Least significant differences (Lsd) at probability level of 5%. Correlation analyses were done to establish the relationship between the variables.

RESULTS AND DISCUSSION

RESULTS

Cattle gender and physiology- based (solid and liquid) manure nutrient quality

Total N and pH responded significantly ($p < 0.05$) to the cattle gender (bulls, lactating cows and heifers), physiological stage and type of manure (solid or liquid), while total P was non significant (Table 1). Solid manure had pH ranging between 7.5 and 8.3, with the bull and lactating cow manure having the highest values. On the other hand, urine had a pH range of 8.7-9, with a bull and lactating cow having higher values than heifer. Furthermore, there was a 38% difference between total N in solid and liquid manure of lactating cow than the bull and heifer. Similarly, the lactating cow had 37 and 11% total P less than that of the bull and heifer, respectively, in urine manure. The same was true in solid manure where the lactating was 30% less than that of both in bull and heifer, (Table 1). However, heifer and bull manures showed higher total N levels than the lactating cow.

Solid and liquid manure and cabbage yield for different gender and physiology

(a) Cabbage shoot yield

Both liquid and solid manure had a significant effect on cabbage shoot yield (Table 2); the former had a stronger effect than the latter. Although the effect of liquid manure continued to be more significant at all levels while that of the solid forms, progressively

became negative to shoot production. Furthermore, the combination of the two manure forms was significant only at higher levels 200+200 (L+S) kg N ha⁻¹. In fact, this combination tended superior to all treatments.

Table 1 Chemical characteristics of cattle manure used in the study
at MUARIK in Uganda

Animal type	Solid manure (composted for 90 days)		
	pH	N (%)	P (%)
Bull	8.3	0.34	0.13
Lactating cow	8.3	0.26	0.10
Heifer	7.5	0.41	0.13
Cattle urine (liquid and fermented for 14 days)			
Bull	9.0	0.36	0.04
Lactating cow	9.0	0.29	0.03
Heifer	8.7	0.42	0.03
Lsd (0.05)	NA	0.028	ns
C.V (%)	NA	7.30	17.70

NA = not applicable

Table 2 Cattle liquid and solid manure *versus* cabbage shoots yield

Treatment kg N ha ⁻¹	Manure form applied (S=solid, L=liquid)	Cabbage shoot yield (t dry wt ha ⁻¹)	Yield increase (% of control)
0	none	4.92	0
50+50	L+S	5.33	8
100	L	5.23	6
100	S	4.64	-6
100+100	L+S	5.32	8
200	L	5.05	3
200	S	4.33	-12
200+200	L+S	5.56	13
Lsd (0.05)		0.74	
CV %		11.9	

L= Liquid (urine) manure, S= Solid cattle manure.

(b) Cabbage head yield

Cabbage head yield responded significantly ($p < 0.05$) to the cattle manure treatments (Table 3). Similarly, the liquid manure maintained the overall superiority at higher rates, while the solid form gradually suppressed the yield. Again, the higher L+S combination rates of (200+200) kg N ha⁻¹ maintained relative superiority to the other combination.

Table 3 Cattle urine and solid manure versus cabbage head yield

Treatment (kg N ha ⁻¹)	Manure form applied	Cabbage head yield (t dry wt ha ⁻¹)	Yield increase (% of control)
0	none	2.336	0
50+50	L+S	2.724	20
100	L	2.452	6
100	S	2.470	6.5
100+100	L+S	2.925	29.5
200	L	2.670	16.5
200	S	2.556	11.5
200+200	L+S	3.118	44
Lsd (0.05)		0.354	
CV %		13.5	

L = Liquid (urine) manure, S = Solid cattle manure.

Cabbage shoot yield under the interactive solid and liquid cattle manure in gender and different physiology

Cabbage shoot yield responded differently ($p < 0.05$) to cattle manure application (Table 5). Heifer manure of 200+200 (L+S) kg N ha⁻¹ had the highest cabbage shoot yield ha⁻¹ with 44% more than the control, and bull manure of 50+50 (L+S) kg N ha⁻¹ had 29% higher than the control. Meanwhile, lactating cow had the lowest yield, 33.5 and 18.2% lower than that of the heifer at application rates 200+200 (L+S) kg N and 200 (L) kg N ha⁻¹, respectively. It was also observed that urine treatments at 200 (L) kg N ha⁻¹ in bull and 100 (L) kg N ha⁻¹ in both heifers and lactating had higher yields compared to solid manure of equivalent proportion (Table 4). Lower combination of solid and liquid manures in bull and lactating categories had 6.5 and 23% higher cabbage yields than that at larger treatment of 200+200 (L+S) kg N ha⁻¹. Meanwhile at 100 (L) kg N ha⁻¹ of liquid manure of bull treatments had 8% higher yield than of a lactating cow. However, urine and solid manure treatment 200+200 (L+S) kg N ha⁻¹ of the heifer was the best and 100+100 (L+S) kg N ha⁻¹ in both bull and lactating had the poorest cabbage shoot yield (Table 4). Nevertheless, female animal gender, generally, had superior cabbage shoot yields to the male (bull) gender (Table 5).

Table 4 Cabbage shoot yield (t dry wt ha⁻¹) under the interactive solid and liquid cattle manure in gender and different physiology

Cattle type	N rates, combinations and application forms								
	0 (None)	50+50 (L+S)	100 (L)	100 (S)	100+100 (L+S)	200 (L)	200 (S)	200+200 (L+S)	Lsd (0.05)
	 kg N ha-1								
Bull	4.59	5.92	5.06	3.97	4.79	5.79	3.75	5.56	
Lactating cow	5.51	5.47	5.12	4.99	4.74	4.22	4.87	4.44	1.29
Heifer	4.66	4.67	5.51	4.97	6.44	5.16	4.36	6.68	

L = Liquid (urine) manure, S = Solid cattle manure.

Table 5 Cabbage shoot yield (t dry wt ha⁻¹) under the influence of solid and liquid cattle manure as well as animal gender

Cattle gender	N rates, combinations and application forms								Lsd (0.05)
	0 (None)	50+50 (L+S)	100 (L)	100 (S)	100+100 (L+S)	200 (L)	200 (S)	200+200 (L+S)	
..... kg N ha-1.....									
Male (Bull)	4.59	5.92	5.06	3.97	4.79	5.79	3.75	5.56	
Females	5.08	5.03	5.31	4.98	5.59	4.59	4.62	5.56	1.07

L = Liquid (urine) manure, S = Solid cattle manure.

DISCUSSION

Cattle gender and physiology- based (solid and liquid) manure nutrient quality

The superiority of heifer and bull solid manure as source of N (Table 1), to the lactating cattle is likely to be to the fact that the efficiency of utilisation of feeds is greater in the lactating than the other cattle groups (Stewart et al., 2005). The lactating animal faces multiple destinations, namely, (i) satisfaction of the animal physiological needs, (ii) the calf or foetal growth and (iii) man through milk harvests.

The relative richness of liquid manure in total N is a common phenomenon (Stewart et al., 2005) depending on the nature of food supplied to the animal. Indeed the low levels of P observed could be because P is largely tied in the organic form of the manure (Zahn et al., 2001; MSU, 2007), or higher reabsorption of P in the kidneys than the large intestines (Wadhawa, 2002). Low solid manure content of N could be due to volatilisation during the composting of manure and the possible leakage of K and P. The

differences in total N content from composted dung and urine manure of dairy cows could be due to non-separations of manures according to both solid/liquid or animal gender and physiology (Flores et al., 2002). However, both solid/and urine compost have yielded to an alkaline condition. These high alkalis could have improved on soil pH, especially from 5.6 to 7.8, which was most favourable for cabbage production above critical level.

On the other hand, heifer uses N and P mainly for protoplasm and bone formation, while in the bull N is used for spermatozoa production and P for bone formation (Neelsesh et al., 2004). Nevertheless, the lactating cow takes a higher proportion of N and P for milk production especially Friesians, which are higher milkers ($20-40 \text{ L d}^{-1}$). It also requires N and P for foetus growth in addition to body maintenance (McDonald et al., 1982).

Solid and liquid manure and cabbage yield for different gender and physiology

(a) Cabbage shoot yield

The lowest shoot dry weight yield obtained in the control treatment during the experiment (Table 2), indicated that low fertility is indeed a limiting factor for cabbage production. The results have also shown that combining solid with liquid manure, leads to an optimum cabbage shoot production. This is because solid manure is particularly acts as a reservoir of nutrients and moisture (Olupot, 2004). This is exhibited by the high cabbage response to the solid and liquid manure treatments 50+50, 100+100, and 200+200 (L+S) kg N ha^{-1} , which is crucial in sustaining the productivity of the low textured with poor drainage and aeration soils of MUARIK (central Uganda) (Zake et al., 1994). Some workers observed that the biomass yield, and content of moisture and crude protein, of Chinese cabbage was highest when fertilised with biodigester effluent and lowest when fresh residual solids from manure were used (Patel, 2003; San Thy, 2005). On the other hand the effect of liquid manure continued to be more significant at all levels than the solid (Table 5) could be due to poor mineralisation by the solid part of the manure (Jay et al., 1995). Therefore, urine manure registered superior to solid counterpart in the cabbage production.

Application of cattle manure (solid and liquid) provides N and P. These two major elements contributed to the higher shoot yield of cabbage. Cabbage shoot enables the crop to accumulate assimilates that will be channelled to cabbage heads during the growth. Any factor that affects dry matter production of cabbage particularly during the vegetative stage reduces its demand for moisture and nutrients. This inevitably affects biomass production and later, head yields. High shoot growth may also promote efficient utilization of light. The biomass generated may also play an important role in providing a final harvestable cabbage head yield. Hence the more developed the shoot the bigger the cabbage head (Vavrina, 2001). Good shoot growth also leads to better soil cover,

reducing soil erosion and nutrient losses around the plants and these factors contribute to higher cabbage head dry weight yield.

(b) Cabbage head yield

The role of manure in moisture and nutrient retention could have accounted for the more than a quarter of head yields obtained under farmers practice (control) The lower yields by solid manure than liquid (urine) (Table 3), could be because solid manures released their nutrients (mineralisation) slowly such that by the time it was at optimum and the crop being annual could have got matured. (MSU, 2007), it takes a gradual breaking down of large molecules to smaller molecules by a succession of soil microorganisms. Energy for this process is obtained from carbon in the material being used. On the other hand, the high combination of 200+200 (L+S) kg N ha⁻¹ registered a yield superior to rest of the treatments (Table 3), could be due to larger proportion of manure applied and hence higher release of nutrients to plants (Jay et al., 1995). Ayoola et al. (2008) observed that, organic manure performs better than other inorganic treatments in cabbage yields due to the synchronisation of nutrient release from solid manure and urine fertiliser with crop uptake. They also reported that fortified cow dung enriched the soil with increased soil N, P and K contents by 25, 1 and 62% respectively. And also increased soil Ca and Mg content by 2 and 8% respectively in maize yield. Faecal manure serves to build up soil's humus and nutrient supplies, which increases significantly with regular application of manure (Abou el-Magd et al., 2005). It is expected that because of the build up in soil humus, solid manure could have a high water retention ability and slow release of nutrients thus making soil water available to and leading to higher cabbage crop yields. However, the urine manure alone could be more economical than the rest of the treatments, because of its faster release of plant nutrients than the solids. However, excessive N, on the other hand, may cause loose cabbage head formation and internal decay (Din et al., 2007).

The heavier cabbage head yields of 50+50, 100+100 and 200+200 (L+S) kg N ha⁻¹ could indicate more head dry matter proportion in the shoot. If less shoot dry matter was left in the garden then more plant nutrients were lost from the soil. This shows that heavy cabbage heads may lead plant nutrient to be over mined from the soil (Anderson et al. 2002). Previous research carried out in Kenya used 10 t ha⁻¹ of farm yard manure obtained 2.716 t dry wt ha⁻¹ yield (Wenjekeche *et al.*, 1998), whereas in this study an average dry weight yield of 3.12 or a range yield of 3.0 to 4.5 t ha⁻¹ was obtained depending on good and reliable rainfall to provide ample water and plant nutrients around the root environment. This was 15 % higher than that of the Kenya record while that obtained from fertilizer application on some research stations was 2.5 t dry wt ha⁻¹ (Beinempaka et al., 1988; Sonko et al., 2005), which was 25% less than that obtained from this research at MUARIK. Similarly, other workers (Panetta *et al.*, 2005; San Thy, 2005) registered the highest biomass of (34 t ha⁻¹), fresh cabbage yield when using the

biodigester effluent compared with composted manure (14 to 17 t ha⁻¹) and the lowest results with fresh solid manure at 9 t ha⁻¹, respectively.

It is therefore, advisable to farmers to use 100 kg N (L) as urine fertiliser for optimal, or else use 200+200 (L+S) for maximum cabbage head yields, despite the yield losses that may occur due to excess N in the latter treatment (Din et al., 2007). Conversely, negatively charged NO₃⁻ does not react with the predominately negatively charged soil particles, so it remains in the soil solution and moves with soil water. Excessive NO₃⁻ may leach out of the root zone during heavy rainfall, (MSU, 2007). It is speculated that urea with excess NO₃⁻-N and NH₄⁺-N in most cases become more injurious to cabbage roots due to their high salt concentration (Charles et al., 1995; White, 1997; Din et al., 2007) hence low yields with high proportion of manure treatment (Tables 4 and 5). This was also observed in the field when cabbage shoots and heads with their stem piths and vascular bundles were rotting (Din et al., 2007), where they were heavily applied with urine/liquid manure.

Cabbage shoot yield under the interactive solid and liquid cattle manure in gender and different physiology

The treatment from heifer registered superior cabbage shoot yield to the bull and lactating cow (Table 4 and 5), because rumen micro-organisms ferment large fractions of proteins to generate energy and a large amounts of ammonia. This is recycled into urea and excreted with urine (Valk et al., 1990). As a consequence, efficient N utilisation by lactating high yielding cow is low unless protein rich diet is supplemented with energy by-products with low protein content. A lot of N and P are taken up for milk production and foetus growth (if in calf) by lactating cow (Ndibualonji et al., 1998; Stewart et al., 2005), hence little is lost through urine and faeces compared to heifer and bulls (Table 4). Nitrogen and P produced by manure when released, help to increase the growth of cabbage, therefore, higher cabbage head and shoot yield, (Tables 4 and 5), (Flores et al., 2002).

CONCLUSION AND RECOMMENDATION

This study has demonstrated that yields increased slightly with increasing manure application. Highest cabbage dry weight yield for urine application of 100 (L) kg N ha⁻¹ is equivalent to 16.6% more than the control and solids are 5% higher than the control yield. Secondly, high combination of solid and liquid manure of 200+200 (L+S) kg N ha⁻¹ has the highest yield of 44% greater than the control and higher than the urine or solid by 17 and 28.5%, respectively.

Similarly a combination of 200+200 (L+S) kg N ha⁻¹ from heifer manure has the highest yield, and is 44% greater than lactating cow. Bull manure is second to heifer. Urine manure of 100 kg N ha⁻¹ is better with 11% more yield than solid of similar quantity.

Heifer and bull manure treatment are both superior to lactating cow, in terms of cabbage shoot and head yields.

Following these conclusions, it can be recommended that MUARIK farm whose soil pH of (5.5-7.5) could be corrected through the application of composted/ and fermented cattle manures (solid/and urine) before one starts growing cabbage on a large scale. And that the 100 (L) kg N ha⁻¹ rate of urine manure is recommended for cabbage production. Large combinations of solid and liquid 200+200 (L+S) kg N ha⁻¹ manure treatment, though can give higher yields, are uneconomical to the farmer, in terms of composting. However, more research is required to reduce the period of solid manure composting to probably 40-60 days. Lastly, farmers are advised to collect urine from heifers and bulls, ferment it for horticultural production since it has higher concentrations of N and P than of lactating cow. Solid manures would be better for perennial crops due to their slow mineralisation process and urine for horticultural crops in peri-urban farming.

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Assessment of Red Ant Organic Management Options in Potato Field of Dhading, Nepal

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ABSTRACT

*Red ants became challenging problem especially in potato crop grown in rainfed areas of mid hills Nepal. It causes high economic losses; and it is quite difficult to manage it with chemical as well as physical management options. Considering these facts, participatory field experiments were conducted in five farmer's fields aiming to find the best organic red ant management options in potato. Botanical leaf extracts were found quite effective than that of chemical as well as control. More than nine times tuber yield damage (31.3 q/ha) was observed in control as compared to Ketuky (*Yucca* sp.) treated field (3.1 q/ha). It is concluded that red ant severely damaged the marketable potato tuber yield but the insect infestation had no effect on potato yield potentiality because there was quite less variation in potato yield.*

Key Words: Pest, *Solanum tuberosum*, *Dorylus orientalis*, *Yucca* sp., *Artemisia vulgaris*, Tuber yield

INTRODUCTION

Nepal is among the poorest and least developed countries in the world with 24.8% of its population living below the poverty line (NPC, 2011). Agriculture is the mainstay of the economy, providing a livelihood for three-fourths of the population and accounting for about one-third of GDP. About 86% of Nepal's population lives in rural areas and depends on subsistence farming for their livelihoods. Household food security and poor nutrition are still major concerns in rural areas. It is need of today to bring a shift from subsistence farming to market oriented commercial farming practices for expanded economic opportunities of the rural population in course of reducing poverty in Nepal. Further, it is inevitable to make the existing farming system more productive, sustainable and self reliant in improving the livelihood conditions of Nepalese peoples. It is estimated that pests cause a loss in food production of about 15-20% (Baker & Gyawali, 1994).

Red ants (*Dorylus orientalis*) have long been known as an important pest of potato in the mid hills of Nepal. The research aimed at introducing the environment friendly red ant management technologies for wider dissemination among the small holding farming communities in Dhading district. An effort was made to identify and assess the repelling status of locally available materials against the red ants in soil biology revealed that few

of the local materials. According to Gyawali (1993), more than 50 species of plants have been identified in Nepal with potential to protect crops and reduce pest damages.

Several workers (Paneru et al., 1993; Lohar & Budhathoki, 1992) have reported the effectiveness of titepati (*Artemisia vulgaris*), Asuro (*Adhatoda visia*), banmara (*Eupatorium* sp), neem (*Azadirachta indica*), and bakaino (*Melia azadirach*) against red ants. Comparative study of chemical pesticides conducted at the Lumle Agricultural Research Centre (LARC) with Chlordane and Phorate, and other cultural practices to control red ants were not conclusive (LAC, 1988). Likewise, in cauliflower drench application with 10 ml solution of 0.03-0.06% Chlorpyrifos (Classic 20 EC) was reported to be effective (GC. et al., 1997).

In recent year, the damage of red ant to agriculture crops is increasing in Nepal. Dhading, a commercial vegetable production pocket area, is very hot spot of red ant infestation. Some farmers have even dropped-out cultivating vegetables due to severe damage of red ant over there. The potato tubers were reported to be heavily infested due to red ant at the time of harvesting. Participatory field experiments were therefore conducted in five farmer's fields with an objective of finding out the best organic options for red ant management.

MATERIALS AND METHODS

This study was conducted in Thakre VDC of Dhading district. The area is located at an altitude of 1200 masl and the soil is red loam with poor fertility status. Participatory field experiments were conducted in five farmer's fields. Selected six treatments (Table 1) including control were replicated in each farmer's field considering Randomized Complete Block Design. Locally available plant materials such as Ketuky (*Yucca* sp.), Sisnu (*Urtica dioca*), Titepati (*Artemisia vulgaris*), and Asuro (*Adhatoda visia*) were tested against red ant damage on potato. They were collected from the experimental sites, where only leaf portion was used in the experimental plots. The damage and density of the red ants was assessed in terms of reduction in the crop yields.

Preparations of extract: Chopped plant materials of treatments 1, 2, 3 and 4 (Table 1) were subjected to fermentation. One kg of chopped plant materials kept with one litre of water in an air-tight plastic bucket for 21 days of each treatment. On the 21st day, nettle extract was obtained by squeezing the content. The filtrate extract from mosquito net was considered as 100% extract which was further diluted with same volume of water before application.

Each plot having 8.1 sq. m. (3x2.7) area was assigned with each treatment. Potato variety MS-42 was used as farmer preferred variety. Tubers having 4-5 germinating buds and 30-40 g in weight were used for planting on 13th of October, 2010. Plants were spaced at 60 cm x30 cm geometry. All the management practices like weeding, earthing-up, irrigation

etc were carried out by the respective farmer as per recommendation. Harvested tubers were categorized into marketable and unmarketable tuber. Yield was weighed and recorded separately. Unmarketable tuber due to infestation of red ants was weighed separately.

Table 1 Details of treatments along with application methods in potato field, 2010

SN	Name of the treatments	Parts used	Application method
1	Ketuki (<i>Yucca</i> sp.)	Leaf & tender stem	Fermented extract drenched & foliar spray
2	Sisnu (<i>Urtica dioca</i>)	Leaf & tender stem	Fermented extract drenched & foliar spray
3	Titepati (<i>Artemisia vulgaris</i>)	Leaf & tender stem	Fermented extract drenched & foliar spray
4	Asuro (<i>Adhatoda visia</i>)	Leaf & tender stem	Fermented extract drenched & foliar spray
5	Chemical (Chloropyriphus)	Market available@ 2 ml/lit. water	Drenching in soil
6	Control	-	-

RESULTS AND DISCUSSIONS

Highly significant difference was observed in red ant damaged yield of potato tuber. There was no significant variation in total tuber yield while marketable yield was significantly differed between treatments ranging from 7.9 t/ha to 10.9 t/ha (Table 2). The results revealed that the maximum marketable tuber yield (108.81 q/ha) was harvested from Ketuky treated field and the lowest yield (79.01 q/ha) was harvested from control. Marketable tuber yield of Ketuky treated plot was significantly higher than that of control. However, the yields obtained from Sishno, Asuro, Titepati and chemical pesticide treated fields were also statistically at par with it. Thus all the treatments gave higher marketable yield as compared to control.

Significant difference was also observed in red ant damaged tuber yield. The Ketuky treated potato tubers were comparatively less damaged (3.62 q/ha) due to the infestation of red ants. However, the value was statistically at par with that of Asuro, Sisno, Titepati and chemical pesticide (Chloropyriphus) treated fields. Red ant severely damaged the potato tuber in control field (31.3 q/ha) which was nearly nine times than that of Ketuky treated field.

There was less variation in total tuber yield as compared to that of marketable and red ant damaged yield. Comparatively less variation in total yield might be due to extreme variation in red ant damaged yield, which has strong negative correlation ($r = -0.88$, $n=30$) with marketable yield. It means that decrease in red ant damaged tuber yield means increase in marketable tuber yield.

Table 2 Red ant damaged and marketable yield of potato under different treatments,
Dhading, 2010

Treatment	Yield (Quintal/ha)		
	Red ant damaged	Marketable	Total
Asuro	5.51 b	106.17 a	111.69
Chemical	12.84 b	86.42 ab	99.26
Control	31.36 a	79.01 b	110.37
Ketuky	3.62 b	108.81 a	112.43
Sishno	6.58 b	109.05 a	115.64
Titepati	12.10 b	91.11 ab	103.21
Grand Total	12.00 b	96.76	108.77
LSD at 5%	8.37**	21.57*	Ns

Values indicated by same letter(s) within the column do not differ significantly at 5% significance level by DMRT

CONCLUSION

The present study projected a way that the botanical plants have some sorts of effects to red ants. Among tested botanicals, Ketuky and Sisnu leaves were found very effective to control red ants in potato field. The chemical compounds present in these botanicals might have some repellent effect to red ants, and that ultimately reduced its infestation. We concluded that these plant materials can be used as botanical pesticides, however, it would be necessary to test and verify the chemical constituents present in these plant materials. This experiment has also indicated the necessity of testing these compounds with standard dose and frequency over the seasons and locations.

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Comparison of Autogenous and Commercial Vaccine for the Protection against Inclusion Bodies Hepatitis

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ABSTRACT

An autogenous vaccine was prepared from Inclusion bodies hepatitis- Hydropercardium syndrome (IBH-HPS) infected liver homogenate by using virus inactivants 0.1% formalin. This vaccine was evaluated with commercial vaccine in 7 groups of broilers (30 in each group) for their comparative protection. The birds of each group were vaccinated with autogenous and commercial vaccine except control group (Group VII). The group I was vaccinated with commercial vaccine and group II with 10% homogenated liver inactivated with formalin autogenous vaccine on 1st day and 10th day of age at dose rate of 0.2ml and 0.5 ml respectively. The group III was vaccinated with commercial vaccine and group IV with autogenous vaccine on 10th day of age with single dose rate of 0.5 ml respectively. The group V and VI were vaccinated with commercial and autogenous vaccine respectively, in normal vaccination schedule at dose of 0.5ml. All 30 birds from each group including control were subjected to challenge test with HPS homologous virus (1 ml 40% w/v infected liver homogenate) after 2 weeks of vaccination and morbidity and mortality were observed. The mortality rates were found significantly lowest in the autogenous vaccine with double dose treated birds and significantly higher in unvaccinated birds ($P>0.05$). It was concluded that formalin inactivated autogenous vaccine prepared from the infected livers of birds which died of natural infection can be recommended for commercial use.

Key words: Inclusion bodies hepatitis- Hydropercardium syndrome (IBH-HPS), Autogenous vaccine, Commercial vaccine, Dose, Protection rate, Mortality rate

INTRODUCTION

Inclusion bodies hepatitis- Hydropercardium syndrome (IBH-HPS) is an important recently emerged immunosuppressive viral disease of poultry, particularly of 3 to 6 week old broiler chicks, characterized by sudden onset, with high mortality ranging from 20% to 70%, typical hydro pericardium and enlarged mottled and friable livers, with intranuclear inclusion bodies (INIBs) in the hepatocytes (Ahmad et al., 1990). The disease is caused by Fowl Adenovirus (FAV) serotype 4, a nonenveloped, icosahedral virus belonging to the adenovirus C species of the Adenovirus genus of the Adenoviridae family (Balamurugan, et al., 2004; Ganesh et al., 2001). Inclusion bodies hepatitis (IBH) is an important, emerging problem in broiler chickens in several countries such as

Australia, New Zealand, England, Germany, Japan, India, Italy, Canada, USA, Mexico and several Central and South American countries (Gomis et al. 2006; Ojkic et al. 2008). Historically, IBH has been identified as a secondary disease in broiler chickens associated with common immunosuppressive agents such as infectious bursal disease virus (IBDV) and chicken infectious anemia virus (CIAV) (Gomis et al., 2006). Pathogenesis of IBH is not clear due to multiple factors associated with its host, pathogen and the environment (Erny et al., 1991; Grimes, 1992; Mendelson et al., 1995; Gomis et al., 2006; Grimes, 2007). IBH was initially identified in broiler chickens with necrotizing hepatitis and intranuclear inclusion bodies (INIB) in the liver (Helmboldt and Fraizer, 1963); later a virus was identified as the etiological agent (Fadly & Winterfield, 1973). The causative agent was suspected to be an adenovirus (AdV) (Bickford et al., 1973; Antillon & Lucio, 1974). Presently, IBH is an important acute, viral infection of broiler chickens aged between 2-7 weeks of age (Adair & Fitzgerald, 2008). Outbreaks of IBH in two-week old broiler breeder chickens (Grimes et al., 1977; El-Attrache & Villegas, 2001; Philippe et al., 2007), and layer chickens (Winterfield et al., 1973; Hoffman et al., 1975) and a case of IBH in a rooster from a specific pathogen free (SPF) flock have been reported (Reece et al., 1986). Numerous factors like flock size, mortality, age and weight at the time broilers are marketed, hygiene, immunization, floor construction and better utilization of available facilities could affect the performance of the broilers (Farooq et al. 2001). Reduction in net profit was observed when mortality level was increased from 2.5 to 10% (Kitsopanidis & Ma, 1991). The disease was first outbreak in 2002 at Gamcha and Gundu areas of Bhakatpur. Later on it was spread to Nuwakot, Dhading, Kabhre, and Lalitpur; and now it is introduced in poultry industries of Chitwan causing high mortality and morbidity. The disease has been reported from Nawalparashi, and Makwanpur. There was no complete control over the disease even though the vaccine was given and timely disease outbreak was noticed in the poultry farm of Kathmandu Valley. In the month of June and July 2009, the veterinarians of Chitwan have experienced an emergence of Inclusion bodies hepatitis in Broilers with mortality is 2-5% daily and morbidity is more than 30% (S. Singh, 5 March, 2009- personal communication). Outbreaks of IBH in the poultry industry of Chitwan cause the economic loss. Standard vaccines are available against most of the poultry disease and also for the IBH but the literature regarding the development and evaluation of autogenous against Inclusion bodies hepatitis virus have been scanty. Therefore, the study is to produce IBH virus vaccine from infected liver homogenate and this vaccine was evaluated and compared with commercial vaccine, in experimental broilers for their comparative immunogenicity in protection.

MATERIALS AND METHODS

Livers and pericardial fluid were collected aseptically during postmortem examination from the cases of Inclusion bodies hepatitis (IBH) outbreak based on the typical gross lesions of the accumulation of straw colored fluid in the pericardial sac and enlarged, pale liver at Veterinary Microbiology Laboratory, IAAS and National Avian Laboratory, Bharatpur. The samples were divided into two parts, half for the virus isolation and half

for the histopathological examination to confirm the disease. One gram of IBH virus infected liver was homogenized with 9 ml of normal saline (pH 7.2) and centrifuged at 3000 rpm for 10 minutes. The clear supernatant was taken out and Gentamycin @ 200 ug/ml, Penicillin @ 1000 i.u. /ml and Streptomycin @ 100 ug/ml were added to the supernatant fluid (Hussain et al., 1996). This 10% infected liver homogenate was stored at -20°C. Formalin was added to the supernatant to obtain a concentration of 0.1% formaldehyde (v/v) to 100 ml of inoculum 0.1 ml of formalin (40% formaldehyde solution) was thoroughly mixed and kept overnight at 4°C in a refrigerator with occasional shaking to inactivate the virus and the material was filtered through 0.4 µm and 0.2 µm membrane filters. It was dispensed in 50 ml aliquotes and stored at 4°C until use (within a month). The sterility of the vaccine was tested by inoculating the material on blood agar, nutrient agar and MacConkey agar plates. Vaccine safety was tested by injecting 1 ml of vaccine subcutaneously in five broiler birds of three weeks of age and observing them for 10 days at the farms for gross pathological changes.

For evaluation and comparison of this vaccine with commercial vaccine, 210 day old broiler chicks of the same breeder flock and same hatching lot vaccinated against Marek's disease were procured and randomly divided into seven groups consisting of 30 birds in each group and replicated thrice containing 10 birds in each replication and were vaccinated with autogenous and commercial vaccine to all groups except control group as shown in Table 1. After 14 days of vaccination, all the birds were given challenge dose of virulent IBH homologous virus (1 ml 40% w/v infected liver homogenate) and mortality and morbidity of all challenged birds were recorded upto 7 days post challenge (PC). From each challenged group, the birds were necropsied at 7th, 9th and 11th days post challenge and observed for any gross pathological changes. Tissue pieces of liver, lungs, kidneys and bursa of Fabricius of each bird were collected separately in 10% buffered formalin for histopathological examination.

Table 1 Vaccine and vaccination schedule of birds of different groups

S.N.	Groups (n=30)	Types of vaccine	Dose
1	I	Commercial vaccine	0.2 ml s/c at 1 day and 0.5 ml at 10 days
2	II	Autogenous vaccine	0.2 ml s/c at 1 day and 0.5 ml at 10 days
3	III	Commercial vaccine	0.5 ml s/c at 10 days
4	IV	Autogenous vaccine	0.5 ml s/c at 10 days
5	V	Commercial vaccine	0.5 ml s/c at 10 days with normal vaccination schedule
6	VI	Autogenous vaccine	0.5 ml s/c at 10 days with normal schedule
7	VII (Control)	No vaccine	

n- Number of chicks

RESULTS AND DISSCUSSION

Different types of chicken with history of IBH in the month of June, July, August and September and mortality that were recorded were as shown in Table 2.

Table 2 IBH cases in Chitwan

Institutions	IBH case	Total case
Institute of Agriculture and Animal Science	20 (28%)	70
National Avian Laboratory	25 (25%)	100
Rastriya Pasupanchi Anweshan Prayogshala	15 (25%)	60
Chitwan Poultry Lab	30 (33.33%)	90

The dead birds showed the characteristic hydro pericardium with enlarged, pale, necrosed liver, congestion of lungs, enteritis, and hemorrhage on heart and kidney. The liver of birds died with IBH had degeneration of hepatocytes with focal areas of mononuclear cells infiltration. The presence of basophilic intranuclear inclusion bodies was demonstrated as large circular masses in the enlarged nucleus. The gross and microscopic lesions observed in the naturally and experimentally infected birds were similar to those recorded by previous worker (Ahmad et al., 1988; Anjuma et al., 1989). The mortality and protection rate is given in table 3. Mortality started after 24 hrs of inoculation and reached up to 4th day of post challenge.

Table 3 Mortality and protection rate of birds after challenged vaccinated groups

Groups	Days after virus challenge					
	Within 24 hours	24-96 hours	After 96 hours	Upto 7 days	Mortality (%)	Protection (%)
I	0	1	1	2/10	20	80
II	0	1	0	1/10	10	90
III	1	1	2	4/10	40	60
IV	0	1	1	2/10	20	80
V	1	1	1	3/0	30	70
VI	0	1	1	2/0	20	80
Control	2	3	3	8/10	80	20

The mortality rate and protection rate is given in table 4 and 5 respectively. The mortality rate was significantly highest in the birds with control treatments within 24 hours vaccinated. At the same period of time, the mortality rate was significantly higher in Group III than group V but with no difference was observed with each other. Rest of other treatments were non significant to each other, and did not respond in the mortality rate of birds. Thus, the mortality rates were found significantly lowest in the Group II treated birds, and significantly highest in the control group. Similarly, among other treatments, the mortality rate of Group III birds was significantly higher than Group I, Group IV, Group V and Group VI but lower than that of control group. The mortality rates were non significant among Group I, Group IV, Group V, and Group VI treatments

but significantly higher than Group II. The protection rate was obtained significantly higher in the birds vaccinated with autogenous vaccine in Group II. Similarly, among Group I, Group III, Group IV, Group VI, and Group V, treatments for the protection rate of birds were significantly lower than Group II. Furthermore, all of them had significantly higher protection rate than that of control treatment (Table 4). In this study, we were able to demonstrate a decrease in mortality of broilers due to IBH by vaccinating the birds with inactivated formalized autogenous vaccine. Although, statistically non-significant, it was observed that immunoprotection was increased against IBH by increasing the vaccine dose of the autogenous vaccine. The protection level of autogenous vaccine with double dose is almost similar as dose of 0.25 ml/bird at 10-15 days of age provided 100% protection (Kumar et al., 1997). The protection level of double vaccinated groups of autogenous vaccine was 90% in comparison with single vaccination groups 80% was similar to the double vaccinated groups 90-100% in comparison to 80-100% in single vaccinated groups (Noor-ul-hasan *et al.* 1994). The mortality rates were found significantly lowest in the Group II birds as compare to the Group I birds. The protection level of single dose vaccine was less effective than the double dose vaccine which is contradictory to report of a single vaccination at 15-18 days of age was more effective in preventing relapses at 35-40 days of age (Ahmad et al., 1990). Ravi Kumar et al. (1997) have reported 100% protection from a single dose of 0.25 ml/bird of vaccine given at 10-12 days of age whereas this study reported that the single dose vaccine did not provide 100% protection in experimental birds. Zia, *et al.* (2001) reported that vaccination with formalin killed IBH vaccine showed 40% mortality compared to commercial oil emulsions IBH vaccine which showed 20% mortality upto day 7 post challenges. In present study the mortality in commercial vaccine is higher than the formalin inactivated autogenous vaccine. This may be due to the fact that our formalin inactivated autogenous vaccine consisted of field outbreak causing IBH virus which may have reasonably high titre as compared to commercially vaccine. Similarly, the mortality rates were found significantly lowest in the autogenous vaccine with double dose (Group II) treated birds and significantly highest in the unvaccinated birds (control) which was almost similar to the mortality in vaccinated birds was 0.52% compared to 5.34% in unvaccinated birds kept on the same premises (Afzal & Ahmad, 1990). Khushi et al. (1996) reported that an inactivated, oil adjuvant vaccine prepared from the adenopak strain (commercial vaccine) isolated in cell culture provided 100% protection against challenge at 42 days of age as compared to inactivated formalin autogenous vaccine. In our study autogenous vaccine gave protection levels for longer time and commercial vaccine with double dose and autogenous vaccine with single dose gave equal response.

Table 4 Mortality rate of birds after challenged vaccinated group

Groups	Vaccine	Mortality rate			
		Within 24 hours	24-96 hours	After 96 hours	Total
I	CVD	0.00c (0.71)	1.00b (1.04)	0.67ab (0.90)	1.67cd (1.28)
II	AVD	0.00c (0.71)	1.00b (1.00)	0.00b (0.71)	1.00d (1.00)
III	CVS	1.00b (1.00)	1.00b (1.00)	1.67ab (1.28)	3.67b (1.91)
IV	AVS	0.00c (0.71)	1.00b (1.00)	0.67ab (0.94)	1.67cd (1.24)
V	NCV	0.33bc (0.80)	1.00b (1.00)	1.33ab (1.14)	2.67bc (1.63)
VI	NAV	0.00c (0.71)	0.67b (0.90)	1.00ab (1.04)	1.67cd (1.28)
Control		2.00a (1.38)	3.33a (1.82)	2.33a (1.47)	7.67a (2.77)
LSD(0.05)		0.2656	0.2824	0.5482	0.3993
SEm ($\pm$)		0.0876	0.0931	0.1807	0.1317
CV (%)		17.78	14.41	29.35	14.34

Note: CVD, Commercial vaccine double; AVD, Autogenous vaccine double; CVS, Commercial vaccine single; AVS, Autogenous vaccine single; NCV, Normal schedule of commercial vaccine; NAV, Normal schedule of autogenous vaccine. Figures with same letter/letters (abcd) within the columns are non significant in 5% level of significance. Figures in the parenthesis are transformed value with square root transformation.

Table 5 Protection rate of birds after challenged vaccinated groups

Groups	Vaccine	Protection rate			
		Within 24 hours	24-96 hours	After 96 hours	Total
I	CVD	100.00a (10.00)	90.00a(69.299)	92.96ab(77.325)	83.33ab(66.147)
II	AVD	100.00a (10.00)	90.00a (71.560)	100.00a(88.499)	90.00a (71.560)
III	CVS	90.00b (9.49)	88.89a (70.963)	79.17bc(63.100)	63.33c (52.777)
IV	AVS	100.00a (10.00)	90.00a (71.560)	92.59ab(79.895)	83.33ab(66.637)
V	NCV	96.67ab (9.83)	89.63a (71.361)	84.72b (68.198)	73.33bc(59.007)
VI	NAV	100.00a (10.00)	93.33a (72.005)	89.63ab(74.576)	83.33ab(66.147)
Control		80.00c (8.93)	57.94b (49.802)	52.78c (46.946)	23.33d (28.777)
LSD (=0.05)		0.4181	4.800	16.95	8.326
SEm ($\pm$)		0.1378	1.582	5.590	2.745
CV (%)		2.46	4.03	13.59	8.10

Note: CVD, Commercial vaccine double; AVD, Autogenous vaccine double; CVS, Commercial vaccine single; AVS, Autogenous vaccine single; NCV, Normal schedule of commercial vaccine; NAV, Normal schedule of autogenous vaccine. Figures with same letter/letters (abcd) within the columns are non significant in 5% level of significance. Figures in the parenthesis are transformed value with square root transformation for within 24 hours and arc sine transformation for other variables.

CONCLUSION

Inclusion bodies hepatitis (IBH-IBH) is an immunosuppressive viral disease of poultry, particularly of 3 to 6 week old broiler chicks, characterized by sudden onset, with high mortality ranging from 20% to 70%, typical hydropericardium and enlarged mottled and friable livers, with intranuclear inclusion bodies (INIBs) in the hepatocytes. Immunization of chickens with live or attenuated vaccines elicited satisfactory protection against the IBH. An inactivated, formalin autogenous vaccine prepared from the homogenated liver given to broiler of 10 days of age provided 100% protection against challenge at 24 days of age. The effect of commercial and autogenous showed that it works well for the protection if given in twice at 10 days interval. It is clear from the results that at earlier age generally vaccinated and control group recorded lower mortality. After 24 hours of challenge the mortality recorded in unvaccinated group of chicken compared to the vaccinated group is higher. The mortality of group that is vaccinated with commercial vaccine is higher than the autogenous vaccine, if given single dose. It was concluded that the fresh liver homogenated autogenous vaccine inactivated with formalin have better protection level than the commercial vaccine.

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Use and Chemical Analysis of Wild Food in Protected Areas of Nepal

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ABSTRACT

*The study was conducted in the surrounding communities of protected areas (PAs) to assess the availability and analyse nutritive value of wild foods. Case studies were conducted in two parks: Shivapuri National Park that represents the hill ecosystem with majority of hill people; and Parsa Wildlife Reserve that represents the sub-tropical ecosystem with majority of Terai ethnic community. Thus the reserved parks have different biological, natural and socio-economic settings. The study revealed that the consumption of wild food was 2.5% (25g/day/person) and on an average 43.4 kg / year. Fish is consumed by almost all community members. Crabs, snails and field rats are not consumed by all members of the community but only by indigenous communities. All the communities consume wild vegetables, eg. Sisno (*Urtica dioica*), niguro (*Diplazium esculentum*) and khole saag (*Rorippa nasturtium*), that contain good amount of minerals (Ca, Fe and P) and vitamin C; and that has substantially contributed to their food security.*

Key words: Wild food, Reserved parks, Indigenous people, Food security

INTRODUCTION

Wild food play great role in the dietary requirements of rural households especially in the context of Nepal. It makes supplemental, seasonal and emergency contributions to household food supplies. It also supplements staple diets, contributing flavor, digestibility of foods, essential proteins, vitamins and minerals. It is not generally dietary staples. However, they can make significant contributions to overall diversity and nutritional quality of the diet. Mostly, poor people and indigenous population have to depend on cheap carbohydrate food such as cereals and potatoes lacking in vitamins and minerals. In this situation, wild food will meet the deficiency of vitamins and minerals, which are freely accessible to the people in protected areas (PAs). During the food shortage period, people collect and consume wild food plants. However, nowadays forest products have declined in terms of quantity, subsequently minimizing the forest products itself.

According to Manandhar (1989) there are 102 useful wild plants used in different regions of Nepal. Daniggelis (1997) reported that wild tubers and potato yam are a staple substitute during winter among Rai and Sherpa ethnicities of Nepal. During winter and

monsoon periods, six and seven types of vegetables are gathered, respectively. More than one half of the Sherpa women eat sisnu and tusa two or three times a week during the monsoon period. The report has also revealed that they fetch sisnu and tusa daily and eat twice a day when they are available. This study has also done analysis of relative amount of nutritive value of the wild food, which is commonly used in the PAs.

METHODOLOGY

Two buffer zones of PAs were selected for this study. The main purpose of selecting 2 buffer zones was to find out overall picture of the Mid Hill and Terai regions status of wild food. Selected VDCs were from urban and rural areas. They were based on inhabitants of indigenous group, the immigrants, and distance from the forest. The stratified random sampling technique was used for a questionnaire survey. At least 20 percent of the total population of buffer zone was selected for household survey.

Food analysis was done by AOAC (1990) method and laboratory manual. Protein was analysed by Micro Kjeldahl Method. Fat was analysed by Solvent Extraction Method. Ash was determined by ignition in Muffle Furnace. Crude fiber was analysed by Acid and Alkali Hydrolysis followed by ashing. Carbohydrate was calculated by different method (100 and sum of moisture, protein, fat, fibre and Ash). Moisture was determined as described in the AOAC Oven method. Crude fibre was determined by AOAC Oven method and total energy was calculated theoretically. Calcium was determined by AAS method (titration method); iron and phosphorus were determined by spectrophotometric method. Vitamin C analysis was done by 2-6 dichlorophenol indophenols Dye Method.

Proximate analysis was done of Khole saag (*Rorippa nasturtium*), Niguro (*Diplazium esculentum*) and Sisno (*Urtica dioica*) at Food Research Lab. AOAC method was used for proximate analysis (AOAC, 1990). Collected samples of wild vegetables were brought to Katmandu, and fresh samples were analysed at the Food Research Lab, Department of Food Technology and Quality Control, Babar Mahal, Kathmandu.

RESULTS AND DISCUSSION

It was found that consumption of wild food depended on various factors. Major factors included availability, cultural habit, palatability, per capita income, time to collect the wild food, and availability of time for going to collect food. All these factors influenced the total consumption of wild food among various community households. The survey revealed that the most used wild vegetables were Khole saag, Niguro, and Sisno. The study therefore analysed the nutritional values of these wild vegetables.

Khole saag, Niguro and Sisno were collected from Shivapuri National Park. The analytical results are translated into nutritive values expressed in terms of values per 100 g of edible portion of sample (Table 1). All the wild vegetables were found to be good

sources of calcium and phosphorus. Crude protein content was high in Sisno (4.1%) and Khole saag (4.35%) as compared to Niguro (0.99%). Iron content was highest (4.70mg/100 g) in Sisno. It is also a good source of Vitamin C (104.47% mg/100 g). Niguro and Sisno contained high amount of phosphorus 117 and 227 mg/100 g, respectively. Niguro was identified as a low calorie (19.39 Kcal/100 g) food item. Obviously, it may be a good food item for the people with diabetes. Almost all (90%) people in surveyed PA consumed wild vegetables as curry and soup.

Table 1 Nutritive value of wild vegetables

SN	Parameter	Sisno	Niguro	Khole saag	Remarks
1	Moisture %	82.07	93.25	90.94	Fresh sample collected from Shivapuri National Park
2	Crude Protein	4.16	0.99	4.35	
3	Crude Fat %	0.32	0.15	0.17	
4	Crude Fibre %	1.75	0.99	2.06	
5	Total Ash %	3.06	1.10		
6	Carbohydrate (g/100 g)	8.64	3.36	1.0	
7	Energy (kcal/100 g)	54.08	19.39	22.93	
8	Calcium (mg/100 g)	-	-	28.48	
9	Phosphorus (mg/100gm)	227	117	86	
10	Iron (mg/100 g)	4.70	1.03	2.0	
11	Vitamin-C (mg/100gm)	104.47	6.20	ND	

ND= not detected

It was found that some 34 and 17 species of wild food (plants and birds/animals) are commonly consumed in PWR and SNP, respectively (Shrestha, 2010). About 37% people use wild plants for medical purpose. However, use of wild plants for medical treatment is reduced nowadays because of the lack of relevant medicinal knowledge.

Table 2 Wild food consumption pattern and rate in study area

Consumption pattern	Consumption rate
Daily consumption g/person	25
Maxium consumption Kg/HH	320
Mnimum consumption Kg/HH	25
Average consumption Kg/HH	43.4

Wild food is used for different purposes. The study found that more than 95.8% households (HHs) consumed wild food such as vegetables, fruits and birds collected from the reserved parks. It was found that 49% (210) of sampled HHs still use to collect wild food from national park inspite of strick law enforcement. They reported that these food items support their life especially during the priod of food/vegetable shortage. Remaining 51% (223) HHs did not collect them from national parks. In some cases, men and women

(46.9%) both collected the wild food. Wild food consumption was found to be 25 g/day/person in a total diet, which is estimated to be 2.5% contribution to food security. Mean estimated annual wild food consumption rate was 43.4 kg / HH (Table 2). Wild foods are important sources of food among indigenous people. Wild food is consumed as palatable spices or vegetables that serves as supplementary food and simultaneously adds vitamins and minerals in the diet of the poor people in study areas. They are nutritional, cheap, and easily available at local level.

CONCLUSION AND RECOMMENDATION

Wild vegetables contain significant amount of minerals and vitamins. It is found that Khole Saag (*Rorippa nasturtium*) contains 28.48 mg/100 g and 86 mg/100 g calcium and phosphorus, respectively. Similarly, Sisno (*Urtica dioica*) contains the highest amount of iron and phosphorous 4.70 mg/100g and 227 mg/100 g. Sisno is found to be the rich source of Vitamin C. Niguro (*Diplazium esculentum*) was identified as a low calorie food item, which is the ideal vegetable for the person with diabetes. Conservation, cultivation and utilisation of these wild vegetables therefore should be promoted to supplement food security of indigenious and marginalised communities in the targeted PAs.

Government should formulate policy for nutritionally and economically valuable wild plant species for farming in community forest, leasehold forest and private land to promote the economic well being of the people for food security.

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Study on Prevalence of Coliform in Goat Meat from Different Meat Shops of Kathmandu Valley

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ABSTRACT

A qualitative as well as quantitative bacteriological study was conducted in Kathmandu valley from September to December 2010 with the objective of finding out the Total Viable Count (TVC) and Total Coliform Count (TCC) in goat meat collected from different meat shops of Kathmandu valley. The conventional culture in agar plate method was used. Out of 101 samples, 97.02% were positive for TVC and 66.33% were positive for Coliform. The mean values of TVC and TCC of dressed goat meat in Kathmandu valley were found to be 1.92×10^7 cfu/g and 3.50×10^5 cfu/g, respectively which were higher than the standard prescribed by the ISO. These also exceeded the standards of Bureau of Indian Standards, i.e. $\leq 10^5$ cfu/g for TVC and 5×10^2 cfu/g for TCC. These findings show unsatisfactory sanitary condition in the local meat markets of Kathmandu valley. The study has suggested the GoN to implement relevant policies and laws.

Key words: Goat meat, Total Viable Count, Coliform Count, ISO standard

INTRODUCTION

Meat and meat products originating from all domestic farm animals except cattle are consumed in Nepal. Among the farm livestock reared by the farmers in Nepal, goats, pigs and broilers poultry are reared specifically as meat animals (Joshi & Shah, 2003). Demand of meat is increasing day by day but it is not enough to meet the national demand; and more than one fifth of the total meat is supplemented by animals imported from India and Tibet. The per capita meat consumption is 8.5 kg. It is lower than that of Asian average (14 kg) and world average (38 kg) (Maharjan, 2009). Meat consumption in urban areas, particularly in the major cities is much higher than the national average, although meat consumption pattern is not similar throughout the country (Shankhi, 2006). Though we do not have developed any standards for the microbial quality of meat in Nepal, we generally follow ISO which has set 105-107 TVC (Total Viable Count) and absent of coliform in 0.01 g for raw meat, and $\leq 10^4$ TVC (Total Viable Count) and absent of coliform in 0.01 g for pre cooked meat (BIS, 1963).

Meat and other meat products contribute significantly to high incidence of food borne disease and zoonotic diseases. Microbes in meat and meat products are the main causes

of food borne diseases in human. The surfaces of raw meats are contaminated with variety of microorganisms. The magnitude of this microbial contamination reflects the microbial population of the environment from where the meat was taken, the method of handling, the time and condition of raw meat. Poor slaughtering facilities and meat handling practices contribute greatly to the spread of disease. Further, poor sanitary condition at herd or flock level, improper screening of disease animals, lairage of abattoirs with deteriorating conditions are very much suitable for the growth of microorganisms and cross contamination of carcass. The presence of extremely large numbers of microorganism suggests that some undesirable events have occurred and that the meat and meat products are indeed susceptible to further deterioration (Prasai, 2001). Meat serves as an excellent medium for the growth of microorganisms. Bryan (1973) listed approximately 200 diseases that transmitted to man by foods. The lists of pathogens which can be transmitted from animals to humans by food contain about 16 kinds of bacteria, 3 groups of viruses, 22 parasites and 5 protozoa (Singh et al., 1995). The microorganisms responsible for lowering the sanitary quality of meat are mainly derived from external environments. The pathogenic bacteria like *Escherichia coli*, *Salmonella* spp., *Clostridium* spp., *Staphylococcus* spp., *Campylobacter* spp., etc. not only spoil meat but also cause food poisoning and other illnesses to consumers. Measures should be adopted in such a way that these organisms should not be present in meat and meat products (Adams et al., 2003).

Access to safe and wholesome meat is a pre-requisite for sound health and well being of people but in current situation of Nepal the quality of meat is very poor. Fresh meat butcher shops are the major retail outlets for meat in Nepal. Main contamination is through unclean water used while transporting and slaughtering. Due to the insufficient supply of clean water in Kathmandu valley, butchers frequently use untreated ground water for meat processing (Prasai, 2001). Nepal has already become a member of the World Trade Organization (WTO). So, safe and wholesome meat is a must in order to be able to compete in the market. Therefore the meat should meet the standards established internationally as per the sanitary and phyto-sanitary (SPS) agreement. The quality management systems like ISO and Hazard Analysis and Critical Control Point (HACCP) are still not followed effectively in Nepal (TLDP, 2003).

As Nepal has not established any standards for goat meat, it is very important to conduct several researches in this area, which ultimately may help establish standards acceptable in Nepalese market. Microbiological aspect is the important factor to study the quality and safety of meat. Only few studies have been conducted on the microbial load in goat meat so far. The present study has mainly focused on the assessment of microbial load as well as isolation of some organisms. The study also compares the microbial load in the samples with international standards.

MATERIALS AND METHODS

This study was conducted from September to December 2010. Both qualitative and quantitative analysis was done. Altogether 101 dressed goat meat samples from different meat shops of Kathmandu, Bhaktapur and Lalitpur districts were collected randomly. All the laboratory analysis was undertaken at the veterinary microbiology laboratory of Institute of Agriculture and Animal Sciences (IAAS), Rampur, Chitwan. A quantity of about 200 grams of cut meat samples were collected and labeled accordingly from the different regions of the carcass, such as brisket, neck and thigh in a sterile plastic bag kept in ice box in the morning time and finally carried to the laboratory for the further processing.

Bacterial flora was isolated from samples according to the methods described in the Bacteriological Analytical Manual of the Food and Drug Administration (updated December, 2007). The conventional culture in agar plate method was used. Basal media, nutrient agar was used along with selective agar, Mac Conkey agar at 37°C for 24 hours. After incubation, the colony counting was done by using microbial digital colony counter. Gram's staining of the pure isolate was done to study on morphology of the cultured organisms.

RESULTS AND DISCUSSIONS

Out of 101 samples, 97.02% (98/101) were found to be positive for TVC and 66.33% (67/101) were found to be positive for Coliform as shown in Table 1. All the isolates were found to be Gram-negative short rods. The prevalence of TVC of this study i.e. 97.02% which is higher than that reported (90%) by Maharjan (2009), but the prevalence of TCC of this study i.e. 66.33% was found to be lower than that reported by CFRL (2000) and Maharjan (2009).

Table 1 Microbial quality of goat meat in Kathmandu valley

S.N.	Parameters	Positive, %	Negative, %
1	TVC	97.02	2.08
2	TCC	66.33	33.67

The mean values of TVC and TCC of goat meat in Kathmandu valley were found to be 1.92×10^7 cfu/g and 3.50×10^5 cfu/g respectively as given in Table 2. The mean value of TVC of dressed goat meat in Kathmandu valley was more than the standard prescribed by the ISO. This also exceeded the standards of Bureau of Indian Standards ($\leq 10^5$ cfu/g). The values of TVC revealed by this study was also higher than that reported by Mukhopadhyay et al. (2004), i.e. 7.61×10^5 cfu/g and Shanki (2006), i.e. 1×10^3 cfu/g; as well as the Standards prescribed by ICMSF (1974), i.e. 7×10^6 cfu/g. But the finding of this study was found to be at par to the result reported by Smith and Palumbo (1973). For the acceptance level, the total viable count should not exceed 2×10^6 cfu/g (Sharma, 1999).

Besides, it is exceeded by the result of this finding which is on the rejection level. As the total microbial load count exceeding 105/g indicates dangerous contamination of food, the meat from Kathmandu valley was found to be unsafe to consumers. The reasons of being higher in the total viable count might be due lack of appropriate slaughtering facilities; unsatisfactory slaughtering and storing techniques; lack of sufficient awareness among meat sellers on hygienic practices besides the relapse of time and need of customers; careless handling of carcass due to ignorance by butchers and meat sellers etc.

Table 2 Mean values of TVC and Coliform of goat meat in Kathmandu valley

S.N.	Parameters	TVC	TCC
1	Mean (cfu/g)	1.92x10 ⁷	3.50x10 ⁵
2	Mean (log ₁₀ cfu/g)	6.14	4.99
3	Standard Deviation	0.24	0.30

The mean value of Coliform of goat meat in Kathmandu valley was found to be 3.50x10⁵cfu/g (Table 2), which was more than the standard prescribed by the ISO. This also exceeds the standards of Bureau of Indian Standards. Furthermore, it was found to be higher than that reported by Mukhopadhyay et al. (2004). This level of coliform contamination reveals that there might be the chances of fecal contamination either from animal itself or human sources. Contaminated water might be another risk factor.

CONCLUSION

Out of 101 goat meat samples from different meat shops of Kathmandu Valley, 97.02% were positive for TVC and 66.33% were positive for Coliform. The mean values of TVC and TCC of goat meat in Kathmandu valley were found to be 1.92x10⁷cfu/g and 3.50x10⁵cfu/g respectively. The values of TVC and TCC were higher than the ISO recommended standard. Obviously, the degree of contamination is at rejection level from food safety point of view.

Improvement in the practices and sanitation in slaughtering and processing of goat meat in Kathmandu valley should get due coinsideration. The GoN should pay due attention in working out / implementing relevant policies and laws.

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Bio-intensive Farming System: Validation of Its Approaches in Increasing Food Production, Improving Food Security and Livelihoods

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ABSTRACT

This paper presents some insight and analysis based on 8-year participatory action research conducted in Udayapur district of Nepal. The study has revealed positive impact of bio-intensive farming system approach in increasing crop diversity and yield efficiency of the farm, improving food/nutritional security and rural livelihoods. Replication of bio-intensive farming system has been recommended as an effective participatory approach to address the issues of land degradation, ecological degradation, food production, food security and livelihoods dimensions in developing countries like Nepal.

Key word: Sustainability, Participatory approach, Cropping intensity, Soil fertility, Yield efficiency, Poverty, Livelihoods

INTRODUCTION

According to the generally accepted global standards, the vast majority of people in Nepal are very much food insecure and have been struggling hard for attaining sustainable livelihoods. The slow growth rate implying stagnation in the agricultural sector during the past four decades has clearly demonstrated the relative failure of past agricultural development policies; and has indicated the urgent need for an alternative approach. In Nepal, population is growing at an average rate of 2.5 percent while food production is fluctuating from a high growth rate of 5 per cent in 1981-85 to 2.2 per cent in 1991-95 and 2.5 per cent in 1996-2000. The per capita food availability, which had been growing strongly at 2.1 per cent in 1981-85 and 3.2 per cent in 1986-90, has shown a negative growth rate in recent decade (Mahbub ul Haq, 2011).

Due to the small size of most farms and the non- farm sector, a large proportion of Nepal's labor force is to be absorbed in agriculture sector through the use of labour-intensive technologies. The choice of crops and farming methods should, therefore, receive priority in participatory research and extension allocations. Likewise, technology that is suited to smaller units of holdings, friendly to the environment, humans, as well as animal, health, and soil microorganisms, and which is beneficial for the improvement of soil fertility, is to be emphasized. Research, extension and financial support programmes are imperative for these purposes, and these programmes need to be planned,

implemented and monitored jointly with local farming community on a partnership basis. Organization and empowerment of farming community groups should, therefore, be the most important component of a new approach for sustainable livelihood.

The socio-economic and political processes of dispossession and disempowerment, the privatization and concentration of resources and income in the hands of a few "rich" people and the consequent erosion of the common property rights and privileges, loss of indigenous seeds and plant/animal genetic resources, the persistently increasing insecurity of food and the increasing economic burden to acquire chemical inputs like fertilizer and pesticides are the major factors precipitating a deep sense of displacement among the rural communities in Nepal. The bio-intensive farming system is a concept that emerged as a response against chemical farming, against the prevailing socio-economic injustice in the agricultural sector, against the "culture of greed", against hunger and poverty (Rajbhandari, 2001). The concept of sustainable bio-intensive farming (BIF) system is based on the agro-ecological principles, indigenous technology and knowledge, experience and need of the people; and on the analysis of the negative impacts of chemical farming elsewhere in this planet (Rajbhandari & Gautam, 1998). Through the BIF system innovation the targeted communities are responding pragmatically to the issues of destruction of the environment, degradation of natural resources, and the consequent loss of a means of livelihood (WOREC, 2009). The bio-intensive farming system approach is an effort to create a new vision and translate that into reality for a mode of sustainable livelihood among the farming communities. Its mission is to transform and reconstruct the farming community with new relations and values towards ensuring food security to the overwhelming majority of the population in Nepal (Rajbhandari, 2002).

In areas of chemically intensive agriculture, problems of salinity, sodicity and water logging as well as the incidence of malaria, schistosomiasis and other water-borne diseases are becoming important. Ground water resources are being adversely affected qualitatively by the excessive use of mineral fertilizers and pesticides (Swaminathan, 1996). It is thus clear that it is not a sustainable and eco-friendly system. As farming has a direct relationship with food security, livelihood and poverty alleviation, our concern about alternative sustainable farming system approaches seems quite pertinent.

POVERTY AND FOOD SECURITY

Poverty is generally defined as a state of deprivation, dependence and degradation below physically and socio-culturally acceptable norms or standards set by a society or nation. These norms or standards are associated with the minimum level of livelihoods. It is a state in which "opportunities and choices most basic to human development are denied to lead a long, healthy, creative life and to enjoy a decent standard of living, freedom, dignity, self-respect and respect for others" (UNDP, 1997). About three quarters of these poor, about 800 million people, live in Asia, primarily in Bangladesh, China, India and

Nepal (Swaminathan, 1996). The largest absolute number of people affected by potentially critical shortage of land is also in Southeast Asia (Ibid). It is in this context that the further complication likely to arise in relation to local, national and global food security systems has to be viewed. FAO (2011) also states that food strategies must not merely be directed at ensuring food security for all, but must also achieve the consumption of adequate quantities of safe and good quality foods that together make up a healthy diet. The policy leaders of SAARC states should keep this context for formulating food security policy for this region.

Nepal is exceptionally food insecure on all of the major indicators of food security. The growing incidence of poverty and food insecurity in Nepal is an outcome of the economic process of a worsening income distribution pattern among the rural households. The social and political processes of denying the marginalized and disadvantaged population groups to having an equitable access to and control over the productive resources, various livelihoods assets and employment opportunities have been further deteriorating the situation of poverty, food insecurity and livelihoods. Besides these weaknesses and challenges, Nepal has a rich natural resource base that include plant and animal genetic diversity, agro-ecological diversity, fresh water originating from the Himalayas, hard-working farmers with indigenous knowledge and skill in farming systems. These facts indicate that Nepal has a good prospect of diversifying and increasing agricultural production and agro-based industrial products for alleviating poverty and attaining sustainable livelihoods. The concept and approach of bio-intensive farming system in Nepal has been developed keeping these realities and scope in mind.

VALIDATION OF THE BIF APPROACH: METHODOLOGY

Who and why should validate BIFS approach? Being a concept and approach that focuses to the needs and perspectives of small farmers, the concept and approach of bio-intensive farming system should primarily be validated by the concerned farmers. And the validation procedure should not be any legal documentation or declaration, rather active engagement of the small farmers in the conceptual understanding; implementation of the approach starting with the establishment of Model Demonstration Farm (MDF); testing new technologies and approaches on the farm; knowledge generation through direct observation, experience and sharing; evaluation and calculation of the advantages/benefits from the approach. This article presents some highlights of the BIF approach and its validation through the shifts in food production and consumption pattern, income generation and food security situation at micro- level (household level). Within the broader framework of the livelihoods, strengthening of social and financial (economic) assets is also dealt with here in. Impact of bio-intensive farming system programme on food security, food consumption pattern, and various aspects of livelihood was assessed based on a household survey in Udayapur district. The total households surveyed were 100, i.e. 50 households each from (a) BIF adopted farmers; and (b)

conventional farmers (taken as control) every year. Household food insecurity scale was computed as suggested by Coates et al (2007).

RESULTS AND DISCUSSION

Addressing livelihoods through social and financial assets building

Farmer's groups (FG) or cooperatives/ farmer's networks (FN), Model Demonstration Farms (MDF) cum Farmer's Field School (FFS) are the major components of BIF system. FGs are the main implementing agencies at local level. Their cooperatives and networks are actively engaged in extension, marketing and advocacy activities. MDF of BIF system is a component developed by B P Rajbhandari in 1992; and that was first implemented in Nuwakot district. It is a space for participatory action research, farmer-to-farmer extension and promotion/development of new technologies. It has also been serving as a FFS where local farmers learn about successful new technologies experimented by the local farmers in their MDFs.

The following indicators of achievements and impacts have validated the appropriateness of the BIF approach for building / strengthening social assets:

- Farmer's groups/cooperatives/networks strengthened
- FG/FN engaged in advocacy for ensuring small/marginalized farmer's rights
- MDF/FFS are attaining success in meeting its goal of extension of sustainable technologies
- Farm household's socio-economic status upgraded
- Soil fertility improved
- Local farm level bio-diversity conserved *in-situ*
- Poverty and food insecurity level declining substantially
- Household livelihoods getting better

Validating the approach through impacts on access and control over quality food

Food availability and purchasing capacity are the important determinants for the food security of the household. In this study, we have perceived food security as a continuous access to safe (non-hazardous) and nutritious food both in terms of quality and quantity to meet the dietary requirement and preference of each member of a HH to live a healthy and productive life. Access of the balanced diet is ensured through consumption of cereals, vegetables, fruits and livestock products in required amounts daily. We have summarized the findings of the study into four major categories, viz. food sufficiency period from own farm production; nutritional security through daily consumption of green vegetables; food security status in terms of absence of worry about availability food stuffs at home; and food insecurity in terms of availability or access to preferred food items at home.

Cropping intensity and yield efficiency

Statistically significant relationships among cropping intensity, crop diversity index (CDI), land utilization index (LUI) and yield efficiency (YE) were reported by Rajbhandari (2010). Positive relationship between cropping intensity and CDI was reported by Duwal (2008) and Shahidullah et al (2006). Duwal (2008) and Sharma (2009) reported that severity of pest damage was more in CFS than in BFS. That resulted in yield decline in CFS. These results have shown positive impacts of bio-intensive farming system in increasing cropping intensity and yield efficiency per unit area owing to scientific crop rotation and IPM followed by the concerned farmers. They have also reported positive indicators in regard to soil structure and fertility in the land where bio-intensive farming has been practiced at least for 5 years.

Food sufficiency

Food sufficiency from own farm production was categorized into commonly used groups like 0-3 month, 3-6 months, 6-9 months, 9-12 months and > 12 months. The results summarized in Figure 1 revealed that, in 2007, nearly 40 percent of BIF households had food sufficiency for 9-12 months and only 12 percent households had food sufficiency for >12 months, i.e. they had some surplus production as well, which enabled them to generate some income. In 2008, the situation was a little bit different among the BIF farmers. The percentage of households with food sufficiency of 1-3, 3-6 and >12 months had increased as compared to previous year.

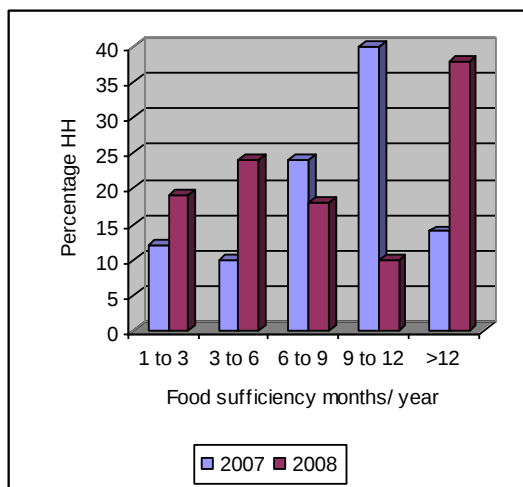


Figure 1 Food sufficiency from own farm production and income

This might be due to the impact of climate change, i.e. late monsoon, less amount of rainfall, and high temperature accompanied with drought in the summer season; and family size. Small farmers (< 0.3 hectare/household), i.e. majority of the sampled households, were more affected by these natural phenomena; and had food sufficiency only for 1-3 months or 3-6 months. The households with relatively larger (>1 hectares/household) or medium (0.5 to 1 hectare/household) land size and access to other inputs, particularly irrigation pumps, were able to cope with the adversity; and had been able to produce food crops more than required for one year.

WOREC Nepal has been providing support for irrigation pumps. Thus BIFS has direct impact on improving the food sufficiency situation in the study areas, where WOREC Nepal has been implementing this programme. The situation was worse among the households with CFS. Quite a big percentage of (55-65%) households had food sufficiency for 1-3 and 3-6 months only.

Shift in vegetable consumption pattern

Nepali people are primarily rice eaters. Traditionally rural people have a tendency of eating big volume of rice and taking vegetable or pulses as a supplement to help eat rice. Indeed, green vegetables are major source of minerals and vitamins and pulse a good source of vegetable protein. Attempt was therefore made to assess the shift in vegetable consumption and pulse consumption patterns among the targeted populations taking them as indicators of better nutritional security. It was found that daily consumption of the seasonal vegetables was more among BIFS growers than CFS growers (Shrestha 2006; Nepal 2007, and Chaudhary 2008). The data presented in Table 1 have revealed that consumption of green vegetables per person was increasing. The percentage of households consuming 210 g vegetables per day per person was only 9 percent in 2006 and it increased to 18% in 2007 and again to 56 percent in 2008.

Table 1 Impact of BIFS on daily HH consumption of green vegetables

Consumption of vegetables per HH g/day (g/person/day)	2006 (a)		2007 (b)		2008 (c)	
	Average Family members	Percent	Average Family members	Percent	Average Family members	Percent
300 (150)	up to 3	8	up to 3	10	up to 3	8
800 (200)	4 -5	80	4 -5	70	4 -5	34
1300 (210)	6- 10	9	6 - 10	18	6 - 10	56
1800 (150)	> 10	3	> 10	2	> 10	2
Total (178)	(6)	100	(6)	100	(6)	100

Sources: (a) Shrestha (2006); (b) Nepal, 2007; (c) Chaudhary, 2008

Note: * FAO Standard for green vegetable =125 g/person/day; potatoes = 85 g/person/day

There are two reasons for this: i. the BIFS farmers have become more aware of the importance of vegetables in their daily diet, and ii. they have been producing varieties of vegetables in their own farm both in the rice-based and maize-based cropping systems and therefore have improved their access to vegetables. This should be taken as a good impact of BIFS on nutritional security of the rural population, particularly the marginalized small farmers and women.

Household food security status

Effect of BIFS in improving the household food security status was quite positive, which is evident from the Figure 2. Household food security status of the farm households engaged in BIFS was significantly higher than those engaged in mainstream conventional farming system (CFS) in 2007 and 2009.

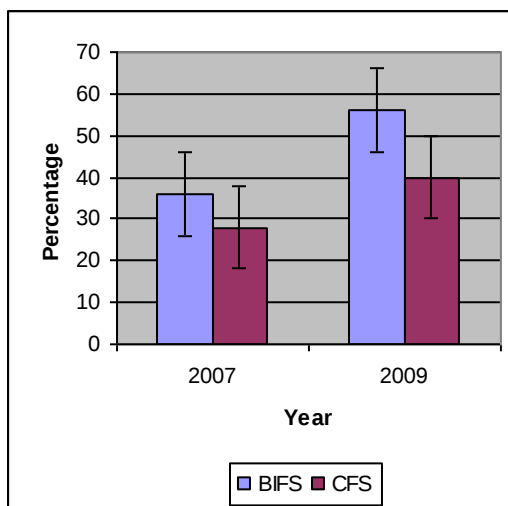


Figure 2 Average household food security status in the study area, Udayapur

Household food insecurity status

Mildly food insecure

Those households that worry about not having enough food, and /or is unable to eat preferred foods rarely, and/or eats a monotonous diets or eats less preferred foods rarely are mildly food insecure. It should be noted that these households does not cut back on the quantity nor experience any of the three most severe conditions. In 2007, it was found that 26 percent of the households practicing the BIFS were found to be mildly food

insecure while this was found to be only 16 percent in CFS adopting farmers. In 2009, percentage of the CFS adopting farm households had increased (Figure 3).

Moderately food insecure

Those households that sometimes or often eat monotonous diets, and/or eat less preferred foods, and or rarely or sometimes cut back the size of meals per day but does not experience any of the three most severe conditions are considered moderately food insecure households. In 2007, it was found that 16 percent of the BIFS adopting farmers and 12 percent of the CFS adopting farmers were found to be moderately food insecure.

Severely food insecure

Those households that often cut back the meal size and number of meal per day and/or experiences (even rarely) any of the above severe cases are considered as severely food insecure. In 2007, it was found that 22 percent of the BIFS adopting farmers and 44 percent of the CFS adopting farmers were severely food insecure, while in 2009, the percentage of the BIFS adopting farmers had gone very low (Figure 3).

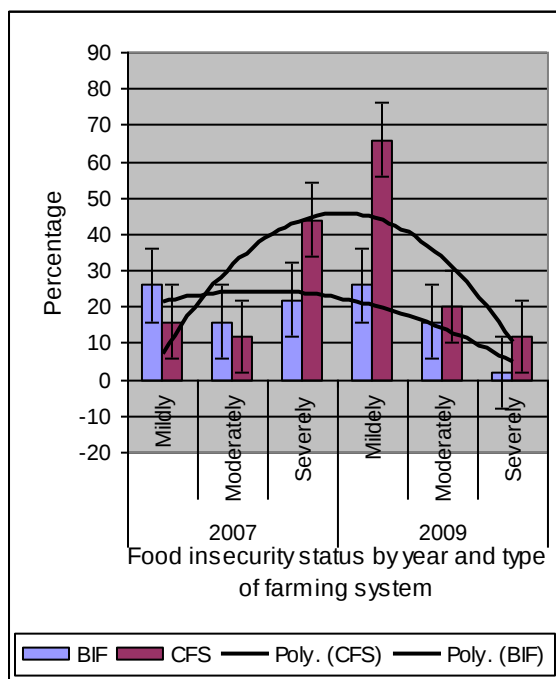


Figure 3 Household food insecurity status by type of farming system and year

It was found that higher the household insecurity access scale (HFIAS) score, higher the food insecurity and vice-versa. Thus, the BIFS adopting households (BIFSAH) with the HFIAS score of 2.58 were found to be highly food secured as compared to the CFS adopting households (CFSAH) with HFIAS score of 5.24 (Table 2). It is obvious from the figures that BIF intervention has significantly (twice) improved the food insecurity situation in targeted areas and communities.

Table 2 Average HFIAS Score of BIFS and CFS

Average HFIAS Score		
Year	BIFSAH	CFSAH
2007	2.58	5.24
2009	4.25	6.82

Livelihoods

Household income from vegetable production

It was found that almost all the farmers adopting BIF used to sell the vegetables and used that money to fulfill the basic needs of the family e.g. education, clothes, etc but very few farmers adopting CFS used to sell their vegetables. The farmers adopting CFS said that the cultivated vegetables were shared with their neighbors and relatives. They argued that vegetable selling is not a tradition in their villages. However, some of the farmers adopting CFS have started selling vegetables. About 30 percent of the respondents adopting BIF had gross annual income of Rs 9000-12000 while 20 percent of the respondents adopting CFS had gross annual income of Rs 1000-3000 (Shrestha 2006). Similar results were reported by Bhandari (2006) and Chaudhary (2005). There were certain constants that were considered during the study in which farmers did not have to invest the money from their pockets and these constants were self produced seeds, organic manure (OM), botanical pesticides, own implements, transportation, land, etc. It was revealed that households with various food security status spent their income from vegetables variously (Figure 4). Those with less months of food sufficiency spent the income for procuring food, while those with food sufficiency of 12 or more months spent the income more for education of the children and farming enterprise. It can be concluded that farmers engaged in BIFS have been able to generate extra income from their farms owing to increased cropping intensity and crop diversity to cope with the worsening food insecurity situation or to invest more for promoting farming enterprise. This can be taken as a good indicator towards sustainable livelihoods.

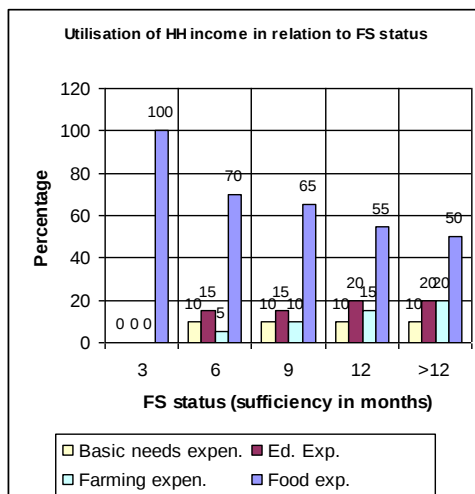


Figure 4 Utilization of HH incomes in relation to FS status among the BIFS adopting households

CONCLUSION AND RECOMMENDATION

Bio-intensive farming system promotes practice of scientific crop rotation, integrated plant nutrient management, integrated pest management that ultimately increase the crop biodiversity and yield efficiency along with conservation/revitalisation of the crop land. This system also improves food security and livelihoods situation of the small farm households.

Bio-intensive farming system is recommended to promote for widespread adoption in other areas or districts of the country. Efforts to promote widespread adoption of BIFS for improving livelihoods and sustainability would require an understanding of how variability among individual, household, farm, and national-level characteristics affect farmers' response to incentives and disincentives.

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